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FACULTEIT PSYCHOLOGIE EN PEDAGOGISCHE WETENSCHAPPEN

Fostering university students' individual and socially shared metacognitive regulation through reciprocal same-age peer tutoring: A study into the impact and interaction processes

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Voorwoord

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Liesje

Gent, februari 2015

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Chapter 1
General introduction

Abstract

The first chapter presents the general introduction to the research theme of the present dissertation. It discusses the conceptual framework that served as a starting point for the empirical studies presented in chapters 2 to 9. The introductory chapter first elaborates on the conceptualisation of metacognition and its key components. Additionally, it outlines the complexity of assessing students' metacognition and discusses the emerging research on social forms of metacognitive regulation. Chapter 1 further elaborates on peer tutoring and on the roles of peer tutors and tutees. It additionally discusses the importance of high-quality peer interactions. Based on the conceptual framework, different challenges for research are outlined and transformed into the research lines and research objectives put forward in the present dissertation. Chapter 1 further provides an overview of the research design and empirical studies conducted to tackle the research challenges. It concludes with a visualisation of the dissertation structure.

Introduction

Contemporary perspectives on learning highlight the need to foster students' problem solving competencies, reflective thinking skills, and self-directed expertise, implying a shift from knowledge transmission to active knowledge construction, aimed at self-regulated and lifelong learning (Bruinsma, 2004; Perry & Winne, 2013; Veenman, van Hout-Wolters, & Afflerbach, 2006; Zimmerman & Schunk, 2011). From this perspective, successful and meaningful learning imply students' adoption of metacognitive regulation (Azevedo, 2009; Butler, 2002; Meijer, Veenman, & van Hout-Wolters, 2006; Pintrich, 2004; Volet, Summers, & Thurman, 2009a). Especially higher education students are required to apply metacognitive regulation skills, since both organisational structures and academic assignments at this educational level emphasise self-management of one's learning (Bruinsma, 2004; Nota, Soresi, & Zimmerman, 2004). Nevertheless, higher education students' metacognitive regulation is often insufficient to adequately self-regulate their learning (MacLellan & Soden, 2006; Nota et al., 2004). Fostering students' metacognitive regulation has consequently become an important educational objective, especially given that adequate metacognitive regulation often advances the depth of learning and correlates with more active cognitive processing, a better understanding, as well as improved performance (Azevedo, 2010; Pintrich, Wolters, & Baxter, 2000; Veenman et al., 2006; Volet et al., 2009a; Winne, 2011; Zimmerman, 2002).

New perspectives on metacognition stress the value of collaborative learning when promoting metacognitive regulation (Hädwin, Järvelä, & Miller, 2011; Vauras & Volet, 2013). Collaborative learning is assumed not only to encourage students into adopting and refining their personal metacognitive regulation, but assumed to engage them in social forms of regulation as well (Iiskala, Vauras, Lehtinen, & Salonen, 2011; Järvelä, Järvenojä, Malmberg, & Hadwin, 2013; Rogat & Adams-Wiggins, 2014). Process-oriented research, aimed at clarifying collaborative learners' adoption of (socially shared) metacognitive regulation through the micro-analytical study of students' interactions, remains, however, scarce (Perry & Winne, 2013; Roscoe, 2014; Vauras & Volet, 2013). The present dissertation builds upon the importance of metacognitive regulation and aims at unravelling and explaining the impact of reciprocal peer tutoring, as a specific form of collaborative learning, on higher education students' adoption of individual and socially shared metacognitive regulation. It more specifically takes a process-oriented research perspective, aimed at advancing the emerging literature on (socially shared) metacognitive regulation in collaborative settings. In the following paragraphs, the theoretical framework and underlying assumptions of the present dissertation are elaborated upon in depth.

Metacognition

The concept of metacognition originates from cognitive information processing theory and was originally defined as an individual's cognition over one's own cognitive activities during learning (Brown, 1987; Efklides, 2008; Flavell, 1979). Although there is general agreement about the importance of metacognition, inconsistency marks its recent conceptualisation, given that a variety of metacognitive terms has unfolded from this broad definition (e.g. metacognitive awareness, metacognitive beliefs, theory of mind, meta-memory, feeling of knowing, self-regulation, etc.) (Azevedo & Hadwin, 2005; Efklides, 2006; Pintrich et al., 2000; Veenman et al., 2006; Zimmerman & Schunk, 2011). In the present dissertation, metacognition is conceptualised as a twofold concept, encompassing both a reflective component (i.e. metacognitive knowledge) and an executive component (i.e. metacognitive regulation) (Brown, 1987; Georghiades, 2007; Pintrich, 2002; Schraw, Crippen, & Hartley, 2006). The reflective component refers to the awareness individual learners have about their general cognitive strengths and weaknesses, about the application of cognitive resources and strategies in order to meet learning objectives, and about the situational appropriateness of particular cognitive resources and strategies. The executive component encompasses the active control learners demonstrate when regulating engagement in learning, adapting to situational learning demands, and optimising learning processes or outcomes (Brown, 1987; Meijer et al., 2006; Pintrich, 2004; Volet, Vauras, & Salonen, 2009b; Winne & Hadwin, 1998).

As depicted in Figure 1, metacognition acts as a meta-level of learning and is related to an object-level of learning (i.e. cognition) through the monitoring and control function (Nelson, 1996; Nelson & Narens, 1994). The object-level refers to cognitive processing activities dealing with the content of learning. On the one hand, there is a permanent flow of information from the object-level to the meta-level, called monitoring. Through monitoring, the meta-level is informed about the state of the object-level. On the other hand, information flows from the meta-level to the object-level, called control. Through the control function, the meta-level instructs the object-level about which step to take next during learning or academic problem solving. For example, when a misinterpretation takes place at the object-level, the monitoring function can give notice of it to the meta-level and the control function can elicit modification of the initial misinterpretation (Efklides, 2006; Nelson, 1996; Veenman et al., 2006). From this theoretical perspective, metacognition has a dual role, both forming a representation of cognition based on monitoring processes and exerting control over cognition based on the representation of cognition (Nelson, 1996; Nelson & Narens, 1994).

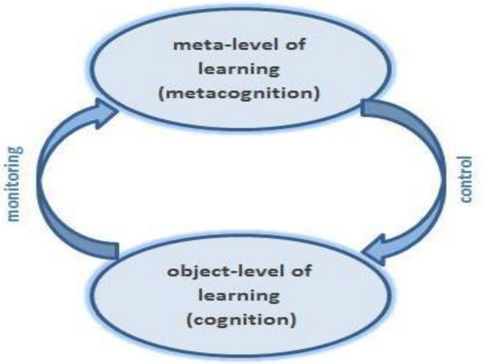

Figure 1. Theoretical model of metacognition (derived from Nelson, 1996)

Traditionally, metacognition has been conceptualised and studied from an individual learner's perspective (Grau & Whitebread, 2012; Hadwin et al., 2011; Vauras & Volet, 2013). Nevertheless, the growing attention paid to collaborative learning in both educational practice and research, pushed the focus to the social context in which learners apply metacognition, evoking theories of social metacognition (Iiskala et al., 2011; Järvelä et al., 2013; Veenman et al., 2006; Volet et al., 2009b). The idea behind this is, that during collaborative learning, cognitive and metacognitive activities are not only demonstrated by individual students, but can be situated at an interpersonal level as well, elicited through social interaction among collaborative learners (Efklides, 2008; Perry & Winne, 2013; Rogat & Adams-Wiggins, 2014; Volet et al., 2009a). With regard to the theoretical model of metacognition outlined above, this implies the inclusion of interpersonal levels of cognition and metacognition (see Figure 2). The interpersonal object-level refers to cognitive activities such as shared meaning making and co-construction of knowledge, whereas the interpersonal meta-level refers to metacognition in which multiple learners are engaged. In a social context, information can be derived from both one's personal and other collaborative learners' cognition and metacognition, evoking both individual (i.e. based on one's own cognition or metacognition) and interpersonal (i.e. elicited by ongoing cognition-oriented or metacognition-oriented interaction with others) monitoring and control. Despite being engaged in collaborative learning, a learner can mainly be concentrated on one's own learning, focussed on checking the state of one's personal object-level through individual monitoring and evoking personally-oriented learning activities through individual control (i.e. curved blue arrows in Figure 2). Similarly, cognitive-oriented interactions among collaborative learners can inform the interindividual meta-level about the state of the interindividual object-level through interindividual monitoring, while metacognitive-oriented interactions can elicit shared cognitive activities through interindividual control (i.e. curved red arrows in Figure 2). Moreover, the ongoing interaction with peers can also trigger an individual learner's metacognition, implying a flow of information from the interpersonal object-level to one's personal meta-level through interindividual monitoring (i.e. straight red arrow in Figure 2). Additionally, an individual learner's meta-level can initiate learning activities at the interindividual object-level through individual control (i.e. straight blue arrow in Figure 2).

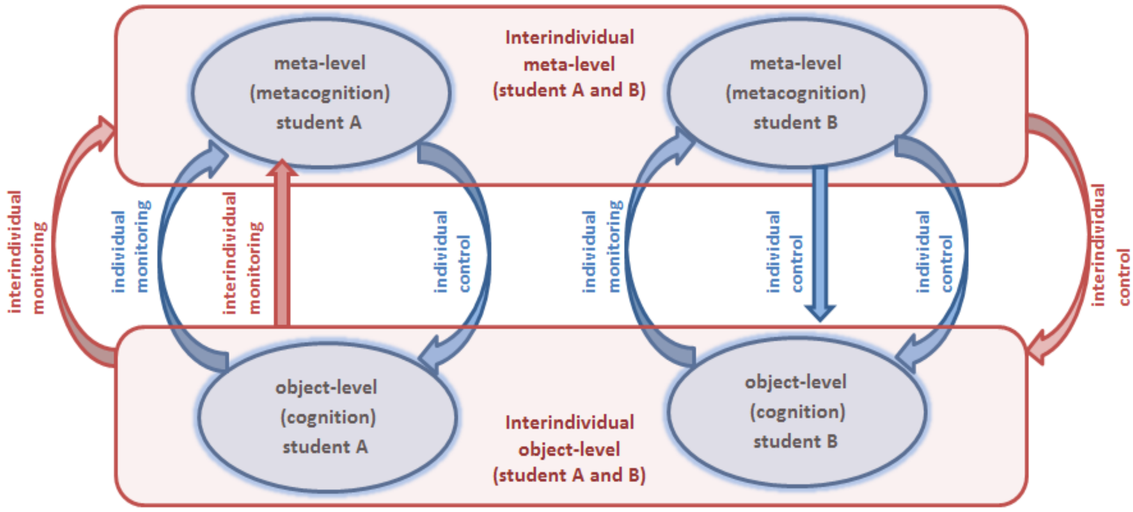

Figure 2. Theoretical model of metacognition in social settings (extended model of Nelson, 1996, based on Efklides, 2008)

Metacognitive knowledge

In the following paragraphs, the key components of metacognition are further elaborated. The first (i.e. reflective) component concerns metacognitive knowledge (Brown, 1987; Efklides, 2006; Veenman et al., 2006). This involves individual students' knowledge of cognition in general as well as awareness and knowledge of one's own cognition, more specifically of the way an individual learner processes information when engaged in learning or academic problem solving (Perfect & Schwartz, 2002; Pintrich, 2002; Zimmerman & Schunk, 2011). Applying metacognitive knowledge is challenging since it requires learners to step back and to reflect upon their cognitive processes (Brown, 1987). Metacognitive knowledge includes three sub-processes that facilitate this reflective aspect of metacognition, more specifically declarative, procedural, and conditional knowledge (Brown, 1987; Schraw, 1998). Declarative knowledge concerns knowledge of the strengths and weaknesses of one's own processing ability as a learner and knowledge about cognitive strategies (Brown, 1987; Georghiades, 2007; Schraw et al., 2006). Procedural knowledge involves knowledge of how to successfully employ particular cognitive strategies in order to achieve learning objectives (Brown, 1987; Perfect & Schwartz, 2002; Pintrich, 2002; Schraw, 1998). Conditional knowledge refers to knowledge of the appropriateness of particular cognitive strategies when taking into account external learning conditions, including awareness of the underlying reasons for cognitive strategies' effectiveness (Brown, 1987; Pintrich, 2002; Schraw et al., 2006; Zimmerman & Schunk, 2011).

As learners become older, they become more aware of their own learning and more knowledgeable about cognition in general (Pintrich, 2002). Consequently, metacognitive knowledge is rather late-developing (Brown, 1987; Perfect & Schwartz, 2002). Nevertheless, it also appears to be fallible, as well as relatively stable once it is established (Pintrich, 2002; Schraw, 1998).

Metacognitive regulation

The second (i.e. executive) component of metacognition concerns metacognitive regulation (Azevedo, 2009; Meijer et al., 2006; Pintrich, 2004; Winne, 2011). This refers to the adoption of self-regulatory skills and related underlying strategies by learners in order to actively and adaptively control, orchestrate, and regulate their cognitive tactics and processes during learning (Brown, 1987; Butler, 2002; Hadwin et al., 2011; Veenman, 2011). In the theoretical model outlined in Figure 1, the regulative component is to be situated in the control function: when information from the meta-level prompts the object-level into a subsequent activity, the learner applies metacognitive regulation skills. Metacognitive regulation involves one of the core processes of self-regulated learning (Efklides, 2008; Meijer et al., 2006; Volet et al., 2009b; Winne, 2011). Although both concepts are frequently used interchangeably (Azevedo & Hadwin, 2005; Veenman et al., 2006; Zimmerman & Schunk, 2011), metacognitive regulation and self-regulated learning are to be interpreted as distinct processes in the current dissertation. Self-regulated learning refers to a learner's deliberate monitoring, regulation, and control of one's cognition, motivation, and behaviour towards the completion of an academic goal, taking into account the particularities of the learning context (Hadwin et al., 2011; Pintrich, 2004; Zimmerman, 2002). It encompasses a multi-faceted process, requiring regulation of a learner's cognition, motivation, and behaviour as well as regulation of the context (Pintrich et al., 2000; Schunk & Zimmerman, 2007; Winne, 2011). On the other hand and in line with the theoretical model in Figure 1, the present dissertation conceptualises metacognitive regulation exclusively as regulation of cognition (Brown, 1987; Meijer et al., 2006; Veenman, 2011; Winne & Hadwin, 1998).

In line with Brown (1987) and Veenman, Elshout, and Meijer (1997), we distinguish orienting, planning, monitoring, and evaluating as key metacognitive regulation skills, which unfold over weakly sequenced and recursive phases during learning or academic problem solving (Greene & Azevedo, 2009; Winne & Hadwin, 1998)[1]. Prior to learning or problem solving, learners ideally *orient* themselves in order to prepare the subsequent execution of cognitive activities (Butler, 2002; Meijer et al., 2006; Pintrich, 2004). During orientation, learners aim to build an adequate representation of task requirements and learning goals, allowing them to purposefully select cognitive strategies in a next learning phase (Butler & Cartier, 2004; Veenman, Kok, & Blöte, 2005; Winne & Jamieson-Noel, 2003). Metacognitive orientation generally encompasses active analysis of the learning task at hand,

[1] It should be noted that monitoring as a regulation skill in the model of Brown (1987) is to be interpreted differently than the monitoring function of metacognition in the model of Nelson (1996), outlined above. In line with Azevedo (2009), Efklides (2008), Pintrich et al. (2000), and Veenman et al. (2006), we acknowledge the different conceptualisations of monitoring in both models but do not consider them incompatible with each other.

in order to get acquainted with task demands and to interpret task instructions, encouraging students to set and reflect upon personal learning goals (Broekkamp & van Hout-Wolters, 2007; Butler & Cartier, 2004; Meijer et al., 2006). Additionally, students can orient themselves more intensively on the content of the learning task by hypothesising on learning contents and by activating prior content knowledge (Butler, 2002; Pintrich, 2004; Veenman et al., 2005). Metacognitive orientation can further involve awareness or explication of learners' task perceptions, resulting in predictions on the task difficulty or one's self-efficacy (Meijer et al., 2006; Pintrich, 2000; Winne & Jamieson-Noel, 2003).

Metacognitive *planning* is closely related to orientation and involves thinking about how, when, and why to anticipate during learning or problem solving (Brown, 1987; Pintrich et al., 2000). It additionally encompasses selecting and sequencing cognitive activities and strategies, allocating resources, and developing action plans in order to attain learning objectives (Bannert & Mengelkamp, 2008; Meijer et al., 2006; Veenman et al., 1997). Although planning generally occurs before commencing a learning task, it can take place at any point in time during learning or problem solving, for example after completing a subtask and commencing the subsequent subtask (Meijer et al., 2006; Pintrich, 2000). Learners' planning activities can moreover be strategic, focussed on selecting a sequence of cognitive strategies after considering various alternatives, or can be rather time-related, focussed on allocating the available time for the subtasks and cognitive activities to be undertaken (Broekkamp & van Hout-Wolters, 2007; Veenman et al., 1997; Zimmerman, 2002). Metacognitively planning one's cognitive activities helps the learner to keep track of his progress during the next phases in learning and facilitates the modification of learning strategies when they appear to have become inappropriate (Pintrich et al., 2000; Veenman et al., 2005).

Metacognitive *monitoring* involves the online quality control of learning or problem solving, aimed at identifying inconsistencies and optimising learners' cognitive activities (Brown, 1987; Meijer et al., 2006; Moos & Azevedo, 2009; Winne, 2011). In general, monitoring can be directed at either learners' understanding, referring to comprehension monitoring, or at the quality of learners' cognitive activities, referring to monitoring of progress (Greene & Azevedo, 2009; Moos & Azevedo, 2009; Pintrich, 2004; Veenman et al., 1997). Comprehension monitoring encompasses controlling the correctness and completeness of one's understanding as well as modifying one's interpretation of learning content or cognitive structures in case these are considered inappropriate (Broekkamp & van Hout-Wolters, 2007; Meijer et al., 2006; Volet et al., 2009b). It can be displayed in learners' thinking out loud and self-explaining their comprehension, which can either raise learners' awareness of incorrect understanding or confirm their interpretation of the learning content, reinforcing their knowledge and cognitive structures (Butler, 2002; Greene & Azevedo, 2009; Pintrich et al., 2000; Veenman et al., 2005). Monitoring of progress involves the ongoing control of the degree to which learners' adoption of cognitive activities is progressing towards the learning objectives set during orientation (Meijer et al. 2006; Moos & Azevedo, 2009; Winne & Jamieson-Noel, 2003). Depending on the perceived discrepancy between the initial learning goal and learners' current progress towards this goal, planned learning activities or problem solving steps can be either modified, continued, or optimised (Broekkamp & van Hout-Wolters, 2007; Pintrich, 2000; Veenman et al., 2005).

Upon completion of learning or problem solving, learners ideally engage in metacognitive *evaluation* (Greene & Azevedo, 2009; Veenman et al.,1997; Winne & Hadwin, 1998). The latter refers to learners' self-judgements directed at either learning outcomes or process-related factors of learning (Butler, 2002; Meijer et al., 2006; Pintrich, 2004). When evaluating learning outcomes, learners can check the correctness, completeness, and effectiveness of their learning products (Bannert & Mengelkamp, 2008; Meijer et al., 2006; Veenman et al., 1997). Evaluation of the learning process encompasses learners' reflections on their execution of action plans and on the appropriateness of adopted cognitive strategies in order to obtain particular learning objectives (Broekkamp & van Hout-Wolters, 2007; Winne & Jamieson-Noel, 2003). Evaluating one's learning can additionally evoke the learner's evaluative perceptions on the task and one's self-efficacy (Meijer et al., 2006; Pintrich, 2004; Zimmerman, 2002). Metacognitive evaluation is further aimed at optimising learners' future adoption of cognitive strategies in transferable learning or problem solving (Pintrich, 2002; Veenman et al., 2005; Zimmerman, 2002). Table 1 summarises the key metacognitive regulation skills, including the underlying concrete regulation strategies.

Table 1. *Overview of metacognitive regulation skills and regulation strategies*

ORIENTATION	
Task analysis	Exploring task demands
	Processing task demands
Content orientation	Generating hypotheses
	Activating prior knowledge
Becoming aware of task perceptions	
PLANNING	
Planning in advance	Formulating problem solving plan
	Selecting problem solving plan
Interim planning	Formulating problem solving plan
	Selecting problem solving plan
MONITORING	
Comprehension monitoring	Noting lack of comprehension
	Summarising main ideas
	Demonstrating comprehension by repeating
	Demonstrating comprehension by elaborating
Monitoring of progress	Checking progress
	Reflecting on progress
EVALUATION	
Evaluating learning outcomes	Checking learning outcomes
	Elaborating on learning outcomes
Evaluating learning process	Commenting on learning process
	Reflecting on learning process

Previous research demonstrated that students' adoption of metacognitive regulation skills is often related to their learning style or approach to learning (Case & Gunstone, 2002; Greene & Azevedo, 2009; Vermunt, 1996). Surface learning appears to be associated with the use of less and rather shallow regulation behaviour, whereas deep learning is generally characterised by a more profound involvement in regulating one's learning (Chinn & Brown, 2000; King, 1998; Roscoe & Chi, 2008; Vermunt, 1996). This finding suggests the existence of possible quality differences in students' metacognitive regulation. Consequently, when evaluating the instructional value of initiatives fostering metacognitive regulation, it is not only important to study the increase in students' adoption of particular regulation skills but to take into consideration the quality of their metacognitive regulation behaviour as well (Rogat & Adams-Wiggins, 2014; Zimmerman & Schunk, 2011). Despite growing consensus on the need to acknowledge (and assess) both the frequency of occurrence and the quality of metacognitive regulation, empirical evidence on regulative quality differences is limited (Greene & Azevedo, 2009; Rogat & Linnenbrink-Garcia, 2011; Zimmerman & Schunk, 2011).

Assessment of metacognition

Given that metacognition operates as a meta-level of learning, measuring students' adoption of metacognitive knowledge and regulation is rather challenging (Azevedo, 2009; Pintrich et al., 2000; Veenman, 2005). Literature reveals a variety of methods for assessing learners' metacognition, including questionnaires (e.g. DiDonato, 2013; King, 1998), observations (e.g. Grau & Whitebread, 2012; Iiskala et al., 2011; Molenaar et al., 2014), stimulated recall (e.g. Vauras, Iiskala, Kajamies, Kinnunen, & Lehtinen, 2003), the analysis of thinking-aloud protocols (e.g. Bannert & Mengelkamp, 2008; Greene et al., 2011), eye-movement registration (e.g. Azevedo et al., 2010; van Gog & Jarodzka, 2013), and on-line computer-log file registration (e.g. Hurme et al., 2006; Järvelä et al., 2013). Depending on the timing of assessment, these methods are clustered as off-line or on-line assessment (Bannert & Mengelkamp, 2008; van Someren, Barnard, & Sandberg, 1994; Veenman, 2005). Off-line assessment takes the form of self-report and is performed prospectively or retrospectively to learning, when students are asked to either predict or recall their use of metacognitive knowledge and regulation skills (Azevedo, 2009; Pintrich et al., 2000; Veenman et al., 2006). On the other hand, on-line assessment is conducted concurrently during learning and allows for behavioural measures of students' metacognition (Bannert & Mengelkamp, 2008; Ericsson & Simon, 1993; van Someren et al., 1994).

Previously, self-report questionnaires were dominantly used in research on metacognition (Pintrich et al., 2000; Veenman et al., 2006; Winne & Perry, 2000). Although they are relatively easy to administer, do not disturb learners' cognitive activities during learning, and are generally appropriate for measuring students' metacognitive knowledge (Bannert & Mengelkamp, 2008; Meijer et al., 2006., 2000; Schraw, 1998; Winne & Perry, 2000), self-report measures often fail to accurately assess students' adoption of metacognitive regulation (Azevedo, 2009; Pintrich et al., 2000; Veenman, 2005). Students not only tend to over- or underestimate their metacognitive strategy use, they often fail to appropriately recall the latter as well (Ericsson & Simon, 1993; Pintrich et al., 2000; Veenman, 2011; Winne & Perry, 2000). Therefore, self-reported metacognitive regulation hardly corresponds with students' actual use of regulation skills (Azevedo, 2009; Bannert & Mengelkamp, 2008; Veenman, 2005). In comparison, on-line assessment, such as think-aloud protocol analysis or observation of students' learning and regulation, allows to capture students' actual adoption of metacognitive regulation more easily, through its direct and micro-analytical focus on the process of learning (Greene, Robertson, & Croker Costa, 2011; van Someren et al., 1994; Vauras & Volet, 2013; Veenman, 2011). Concurrently assessing students' metacognitive regulation is therefore less vulnerable to students' memory distortions (Pintrich et al., 2000; Veenman, 2011; Winne & Perry, 2000). Nevertheless, the limitations of both think-aloud protocol analysis and observations should be acknowledged as well. Since the former is based on students' verbalisation of cognitive activities, think-aloud measures might be incomplete given that students not always explicitly verbalise their cognitive activity (Bannert & Mengelkamp, 2008; van Someren et al., 1994; Veenman, 2005). Additionally, asking students to think aloud might prompt them to verbalise more and other cognition and regulation then they would spontaneously demonstrate (Ericsson & Simon, 1993; Greene et al., 2011). In comparison, observation generally interferes less with students' learning (Bannert & Mengelkamp, 2008; Veenman, 2011). However, identifying students' covert metacognitive processes through observation remains difficult (Pintrich et al., 2000; Veenman, 2005; Vauras & Volet, 2013). It should further be acknowledged that on-line assessment of students' metacognitive regulation provides rich and detailed information but is time- and labour-intensive as well, making it less suitable for use in larger samples (Azevedo, 2009; Ericsson & Simon, 1993; Veenman et al., 2006). Although compromising between sample size (i.e. representativeness of data) and depth of analysis remains a methodological challenge in metacognition research, recent literature is clear on the need for on-line assessment of students' metacognitive regulation, particularly when assessing collaborative learners' adoption of (social forms) of metacognitive regulation (Hadwin et al., 2011; Järvelä et al., 2013; Vauras & Volet, 2013). The present dissertation builds upon the strength of online-assessment methods, by identifying students' metacognitive regulation by means of think-aloud protocol analysis and concurrent observation during collaborative learning.

Metacognitive regulation can benefit students' learning

In educational research, it is widely acknowledged that students' metacognition, and more specifically their adoption of metacognitive regulation, directly advances students' learning and performance (Azevedo, 2009; Schunk & Zimmerman, 2007; Veenman et al., 2006; Winne, 2011; Zimmerman, 2002). Adequate metacognitive regulation correlates with better comprehension of the subject matter (Ford, Smith, Weissbein, & Gully, 1998; Pintrich et al., 2000; Wolters, 1999; Zimmerman, 2002) due to students' more active involvement and deeper cognitive processing during learning (Georghiades, 2007; Prins, Veenman, & Elshout, 2006; Winne, 2011). Metacognitively regulating one's learning makes students more cognizant of their understanding (Bartels & Magun-

Jackson, 2009; Isaacson & Fujita, 2006; Tobias & Everson, 2002; Zimmerman, 2002) and prompts them to select and adopt more effective cognitive strategies for reasoning and problem solving (Ford et al., 1998; Koriat, 2012; Pintrich et al., 2000; Wolters, 1999). Applying metacognitive regulation also appears to correspond with more extensive and more profound knowledge acquisition (Ford et al., 1998; Georghiades, 2007; Wolters, 1999), as well as with improved performance (Coutinho & Neuman, 2008; Prins et al., 2006; van der Stel & Veenman, 2010), often resulting in higher academic achievement (Georgiades, 2007; Isaacson & Fujita, 2006; Veenman, 2005). Metacognitively regulating learning further correlates with high-level thinking and is often associated with deep approaches to learning (Case & Gunstone, 2000; Greene & Azevedo, 2009; Isaacson & Fujita, 2006). Further, it is also assumed to facilitate transfer of learning (Georghiades, 2007; Volet et al., 2009a; Zimmerman, 2002). Additionally, empirical evidence revealed a positive relationship between students' metacognitive regulation and higher levels of self-efficacy (Ford et al., 1998; Isaacson & Fujita, 2006; Zimmerman, 1990). Learners who metacognitively regulate their cognition also approach academic tasks with more confidence (Zimmerman, 1990) and demonstrate higher motivation for learning (Isaacson & Fujita, 2006; Pintrich et al., 2000; Schunk & Zimmerman, 2007; Tobias & Everson, 2002), as well as intrinsic interest in learning and academic problem solving (Zimmerman, 1990).

Since effective metacognitive regulation makes learners cognizant of the (in)appropriate nature of their cognitive actions, which promotes meaningful learning (Bartels & Magun-Jackson, 2009; Prins et al., 2006; Van der Stel & Veenman, 2010), improving students' metacognitive regulation has become an important objective in education (Azevedo, 2009; Veenman et al., 2006; Winne, 2011).

Metacognitive regulation during collaborative learning

Collaborative learning as a fruitful environment

Students demonstrate considerable variation in their metacognitive adequacy, often revealing a need to foster or optimise their metacognitive regulation (Bruinsma, 2004; Nota et al., 2004; Veenman et al., 2006). Empirical research demonstrates the importance of learning through guided practice when aiming to promote learners' metacognitive regulation and highlights modelling, prompting, extended training, and reflection as key components of metacognitive instruction (Hadwin, Wozney, & Pontin, 2005; Schraw et al., 2006; Veenman et al., 2006; Volet et al., 2009b). Initially, students' metacognitive awareness should be raised through observation of modelled metacognitive regulation during social interaction (Hurme, Palonen, & Järvelä, 2005; Schraw, 1998; Schunk & Zimmerman, 2007). Additionally, students should be prompted to extensively practice and internalise the modelled regulation behaviour (Hadwin et al., 2011; Roscoe, 2014; Schraw et al., 2006), as well as to reflect upon and consequently fine-tune a variety of regulation skills (Efklides, 2008; Hadwin et al., 2005; King, 1998; Volet et al., 2009b). Collaborative learning is in this context assumed to be promising to foster students' metacognitive regulation (Goos, Galbraith, & Renshaw, 2002; Hurme et al., 2006; Järvelä et al., 2013; Vauras & Volet, 2013). Shared knowledge construction and joint problem solving challenge students to discuss and regulate their own and each other's cognitive activities, providing an opportunity to practice with and refine one's own metacognitive adequacy, based on the observation of collaborating peers' regulation behaviour (Iiskala et al., 2011; King, 1998; Roscoe, 2014; Volet et al., 2009a; Webb & Mastergeorge, 2003).

Social forms of metacognitive regulation

Traditionally, metacognitive regulation has been studied at the level of an individual learner (Grau & Whitebread, 2012; Iiskala et al., 2011; Veenman et al., 2006). Despite acknowledging the facilitative role of social interactions and collaboration with peers, prior research aimed at understanding the processes collaborative learners adopt to successfully regulate their personal learning (Efklides, 2008; Hadwin et al., 2011; Perry & Winne, 2013). Recently, however, collaborative learning groups are increasingly conceptualised as unique social systems, which can evoke and simultaneously demand for metacognitive regulation at different levels of social interaction (Iiskala et al., 2011; Järvelä et al., 2013; Volet et al., 2009b). As a result, an innovative line of research on social forms of regulation, particularly socially shared metacognitive regulation, is emerging in the metacognition research (Molenaar, Sleegers, & van Boxtel, 2014; Rogat & Adams-Wiggins, 2014; Vauras & Volet, 2013).

Collaborative learning has the potential allowing students to jointly engage in metacognitive regulation with peers. Depending on the level of reciprocity within such joint regulation, (asymmetrical) co-regulation and (mutual) socially shared metacognitive regulation are distinguished (Iiskala et al., 2011; Järvela et al., 2013; Perry & Winne, 2013; Volet et al., 2009a). During metacognitive co-regulation, one student regulates other students' learning by explicitly instructing or prompting them into regulation activities (Grau & Whitebread, 2012; Hadwin et al., 2005; Rogat & Adams-Wiggins, 2014). Metacognitive co-regulation consequently results in an unequal distribution of metacognitive engagement among collaborative learners. The initiative-taking student's regulative acts are influenced by intra-individual goals but directed at other students' learning (Järvelä et al., 2013; Perry & Winne, 2013; Volet et al., 2009b). Although co-regulation might foster an individual student's personal metacognitive regulation, it should not necessarily be interpreted as a transitional phase in the development of a learner's self-regulation (Rogat & Adams-Wiggins, 2014; Volet, Vauras, Khosa, & Iiskala, 2013).

When multiple collaborative learners reciprocally discuss and share learning objectives, mutually monitor each other's comprehension and the group's progress, and collaboratively reflect upon their collaboration and learning outcomes, they engage in socially shared metacognitive regulation (SSMR) (Iiskala et al., 2011; Järvelä et al., 2013; Perry & Winne, 2013; Rogat & Adams-Wiggins, 2014; Volet et al., 2009b). As depicted in Figure 3, SSMR is a more intensive social form of metacognitive regulation compared to co-regulation. Although initiated by an individual student's regulative acts, SSMR is characterised by subsequent involvement in metacognitive regulation of multiple collaborating peers reciprocally operating on each other's regulative acts in a spiral-like process (Grau & Whitebread, 2012; Iiskala et al., 2011; Rogat & Linnenbrink-Garcia, 2011; Volet et al., 2009a). It requires collaborative learners' shared metacognitive awareness and is directed by a collectively negotiated understanding of group level activities (Hadwin et al., 2011; Volet et al., 2013).

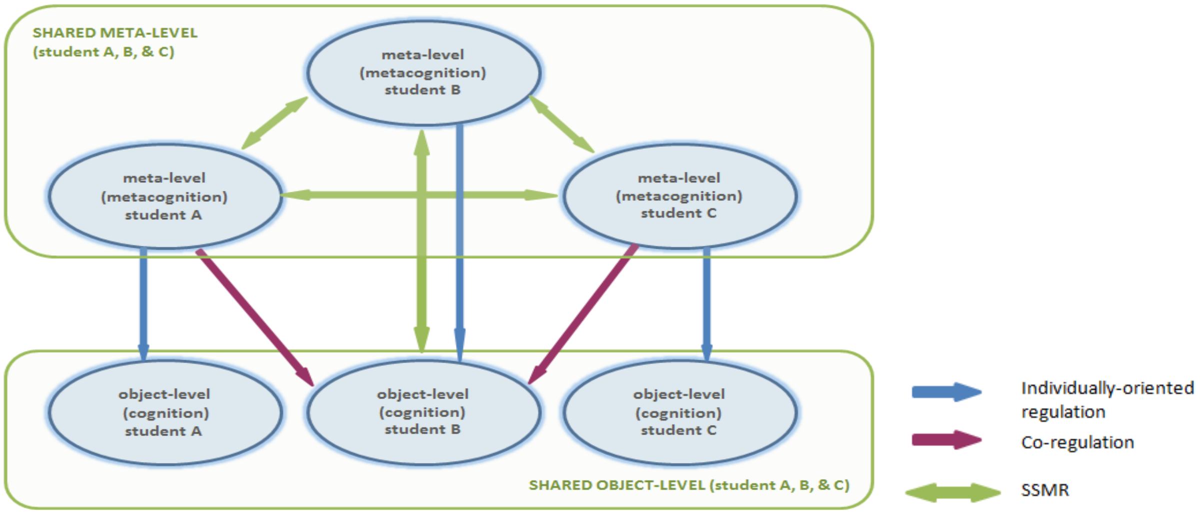

Figure 3. Examples of social forms of metacognitive regulation

There is growing consensus that successful collaboration is related to learners' coordinated and mutual engagement in regulating learning (Iiskala et al., 2011; Lajoie & Lu, 2012; Volet et al., 2009a). Adopting SSMR results in better group performance (Chan, 2012; Järvelä et al., 2013), as well as in increased reflection on and understanding of individual students' mental models (Chan, 2012; Iiskala et al., 2011; Lajoie & Lu, 2012). By promoting reflection, SSMR can also enhance students' ability to effectively self-regulate their personal learning, benefitting their academic performance (Chan, 2012; DiDonato, 2013). Nevertheless, the research on SSMR is still in its infancy. Prior studies mainly focussed on differentiating self from social forms of regulation and on the methodological challenges of analysing SSMR (Perry & Winne, 2013; Rogat & Adams-Wiggins, 2014; Vauras & Volet, 2013). To date, however, little is known about the impact of adopting SSMR on students' learning (both at the individual and group level), or about which contextual features influence collaborative learners' engagement in SSMR.

Scaffolds supporting students' adoption of metacognitive regulation

Successfully regulating collaborative learning with peers in open-ended learning environments appears to be challenging and often requires time and additional support (Azevedo & Hadwin, 2005; Molenaar et al., 2014; Perry & Winne, 2013). Since metacognitive scaffolds direct students' attention towards particular regulative acts, they might be valuable to optimise collaborative learners' adoption of (social forms of) metacognitive regulation (Bannert & Reimann, 2012; Manlove, Lazonder, & de Jong, 2007).

Scaffolding was originally conceptualised as dynamic assistance provided by a more knowledgeable person to a novice learner, aimed at helping the learner succeed in activities he is unable to successfully accomplish independently and at fading the assistance as the learner's competence increases (Collins, Brown, & Newman, 1989; Pea, 2004; Puntambekar & Hübscher, 2005; Wood, Bruner, & Ross, 1976). Scaffolding requires on-going diagnosis of students' understanding and calibrated support, adapted to students' progressive level of understanding and faded as students become more capable of independent learning (Azevedo & Hadwin, 2005; Collins et al., 1989; Pea, 2004; Puntambekar & Hübscher, 2005; Wood et al., 1976).

With computer-based learning taking a central place in educational research, scaffolding has increasingly been narrowed down to instructional tools, designed to help students learn successfully (Azevedo & Hadwin, 2005; Puntambekar & Hübscher, 2005). This recent conceptualisation often abandons the intrinsically dynamic nature of scaffolding, favouring the notion of "scaffold" to describe fixed prompts and hints which operate as strategy activators (Berthold, Nückles, & Renkl, 2007; Pea, 2004). Metacognitive scaffolds should be considered as supportive aids and instructions which require students to carry out particular regulative acts that they are capable of but do not always demonstrate spontaneously (Bannert & Reimann, 2012; Manlove et al., 2007). As such, they aim at advancing students' learning by prompting them into identifying task demands, activating prior knowledge, selecting learning strategies, controlling comprehension and progress, and evaluating learning (Azevedo & Hadwin, 2005; Berthold et al., 2007; Molenaar et al., 2014). Although scaffolds have demonstrated their instructional value to enhance students' learning and understanding (e.g. Bannert & Reimann, 2012; Berthold et al., 2007; Manlove et al., 2007), little empirical evidence is available on their effectiveness for eliciting particular regulation behaviour, more specifically collaborative learners' adoption of social forms of metacognitive regulation (Azevedo & Hadwin, 2005; Molenaar et al., 2014).

Peer tutoring

Peer tutoring and the roles of tutor and tutee

Collaborative learning through peer tutoring

Since the promotion of learning and regulation requires explicit modelling and intensive guided practice, increasing student-staff ratios challenges higher education teaching resources to successfully support students' learning and metacognitive regulation (Bruinsma, 2004; Topping, 1996). The current widespread implementation of student-activating instructional approaches, particularly collaborative learning, demonstrates that interactively learning by collaborating with other students could be a valuable alternative. Collaborative learning refers to an instructional approach in which students academically work together towards a common goal in small groups or student pairs, and learn by interacting with each other (Barron, 2003; Dillenbourg, 1999; King, 1998).

In order to be successful, collaborative learning should be structured up to some extent (e.g. by providing students with scripts or assigning them roles) (Barron, 2003; Dillenbourg, 1999; Webb & Mastergeorge, 2003). Although collaborative learning environments are manifested through a great variety of formats (e.g. differing in group size, composition, pursued learning objectives, supporting tools, division of tasks, role taking, etc.), they all require a level of mutual engagement and particular forms of social interaction directed at explicating and sharing meaning, asking questions, conceptually discussing learning content, providing feedback, explaining, and collectively making decisions (Barron, 2003; Roscoe & Chi, 2008; Webb & Mastergeorge, 2003). These interpersonal activities are assumed to trigger interpersonal cognitive and regulative processes, encouraging students' active and purposeful co-construction of knowledge and acquisition of skills (Hurme et al., 2006; King, 1998; Roscoe, 2014; Topping, 2005). The small-scale setting of a collaborative learning group moreover allows for intensive modelling by peers and individualised feedback on internalised learning and regulation behaviour, stimulating reflection and optimising students' (regulation of) learning (Barron, 2003; Chi, Siler, Jeong, Yamauchi, & Hausmann, 2001; Dillenbourg, 1999; Volet et al., 2013).

One of the longest established, frequently implemented, and empirically studied formats of collaborative learning concerns peer tutoring (Falchikov, 2001; Roscoe & Chi, 2008; Topping, 1996). Peer tutoring is aimed at active acquisition of knowledge and skills through carefully organised and partly structured collaborative learning among peers, or people from similar social groups who are not professional teachers, in either dyads or small groups (Duran & Monereo, 2005; Topping, 2005). Peer tutoring is more specifically characterised by particular role taking of the students involved. One student, the peer tutor, is more knowledgeable and experienced (either naturally or by being provided with additional resources) and is consequently expected to take a direct pedagogical responsibility by adopting a supportive role (Falchikov, 2001; McLuckie & Topping, 2004). The peer tutor is more specifically assumed to create learning opportunities in the peer tutoring group through questioning, clarifying, stimulating reflection, and actively scaffolding other peers' learning (Chi et al., 2001; Duran & Monereo, 2005; Roscoe & Chi, 2008). The less experienced students being cognitively challenged and receiving academic help from peer tutors, are called tutees (Falchikov, 2001; Topping, 1996). Whereas the peer tutor is responsible for managing peer interactions and facilitating tutees' learning, the tutees are primarily occupied with sharing meaning, co-constructing knowledge, and practicing with learning and regulation skills. Receiving academic support consequently does not imply that tutees take a passive role (Duran & Monereo, 2005; Roscoe, 2014; Topping, 2005). Peer tutors' deliberate support directly helps tutees to achieve learning objectives, but also challenges and fosters peer tutors' understanding of their own learning, providing input to optimise the latter. Consequently, successful peer tutoring is advantageous for both peer tutors and tutees.

From tutor-directed to tutee-centred learning and regulation

Although peer tutors generally guide and facilitate tutees' learning, their support is expected to evolve over time, generating a gradual transition from directive (i.e. external) to facilitative (i.e. internal) learning and regulation (De Smet, Van Keer, & Valcke, 2009; Falchikov, 2001; Hadwin et al., 2005). Accordingly, tutees are expected to demonstrate enhanced engagement and initiative for learning and regulation as they gain more experience and expertise in the peer tutoring setting.

Initially, the peer tutor predominantly initiates and controls tutees' learning, as tutees enter the peer tutoring setting as novices, both with regard to domain-specific knowledge and the regulation of collaborative learning processes (Pata, Sarapuu, & Lehtinen, 2005; Rasku-Puttonen, Eteläpelto, Arvaja, & Häkkinen, 2003). At this initial stage, the peer tutor acts as a model, dominating group interaction, explicitly prompting tutees' learning, and demonstrating (i.e. modelling) how particular learning and regulation strategies can be executed (Hadwin et al., 2005; Schmidt & Moust, 1998). As tutees gain more experience and expertise, the peer tutor's support evolves towards coaching behaviour (De Smet et al., 2009; Schmidt & Moust, 1998). A coaching peer tutor's interventions are less directive but rather aimed at guiding and facilitating tutees' self-directed knowledge-construction. As a coach, the peer tutor indirectly prompts tutees' learning, while tutees start to manage peer interactions and increasingly initiate conceptual discussions (Pata et al., 2005; Rasku-Puttonen et al., 2003). At this stage, tutees also gradually take ownership of regulating the group's learning (which was previously modelled by the peer tutor) although they still rely on the tutor to assist them to take full responsibility in this respect (Hadwin et al., 2005). Ultimately, the peer tutor's support fades out when taking the role of consultant (De Smet et al., 2009; Schmidt & Moust, 1998). At this stage, tutees have sufficiently internalised and automated cognitive, communicative, and metacognitive strategies to take full ownership of their own and each other's learning and to regulate group processes independently (Hadwin et al., 2005; Rasku-Puttonen et al., 2003). The consulting peer tutor's interventions are therefore merely aimed at fine-tuning and optimising tutees' internally initiated learning and regulation (De Smet et al., 2009; Hadwin et al., 2005).

Variations of peer tutoring

In recent decades, different typologies of peer tutoring came to the fore, as the implementation of diverse peer tutoring formats in educational environments increased (Falchikov, 2001; Topping, 2005). Besides differences in curriculum content, preliminary training, provided structure, intensity, or objectives, peer tutoring settings can be conceptualised as face-to-face or online, same-age or cross-age, and fixed or reciprocal, depending upon contextual characteristics of the learning environment (Topping, 1996). The focus of the present dissertation is more specifically on same-age, reciprocal peer tutoring in a face-to-face context.

The peer tutoring concept originates from face-to-face settings, but has recently been re-conceptualised with computer-supported collaborative learning taking a central place in educational practice and research (De Smet et al., 2009; Falchikov, 2001; McLuckie & Topping, 2004; Topping, 2005). Face-to-face and online contexts each establish specific interaction dynamics, resulting in different learning experiences for the students involved. Whereas face-to-face collaboration is often characterised by more hierarchical interactions between peer tutors and tutees, it also facilitates higher-order learning, through peers' immediate and mutual response to each other's thinking, stimulating reflection during sequences of reciprocal conversational exchanges (Chi et al., 2001; King, Staffieri, & Adelgais, 1998; Roscoe, 2014). On the other hand, online discussions appear to be more egalitarian, but are often short and non-reciprocal, aimed at reviewing instead of processing information (Molenaar et al., 2014; Pifarré & Cobos, 2010).

Students participating in peer tutoring can be grouped either with peers from their own class group in same-age or same-ability peer tutoring, or with younger, rather older peers from different grade/class groups during cross-age or cross-ability peer tutoring (Duran & Monereo, 2005; Falchikov, 2001; Topping, 1996)[2]. Most peer tutoring programmes engage older (i.e. cross-age) peer tutors to academically support younger tutees (Duran & Monereo, 2005; Falchikov, 2001). Despite its inherent difference in tutors' and tutees' domain-specific knowledge – which facilitates appropriate scaffolding and successful tutoring (Roscoe & Chi, 2008; Topping, 1996) – cross-age peer tutors are often attributed a higher social status by their tutees (Colvin, 2007; Robinson, Schofield, & Steers-Wentzell, 2005), possibly establishing an asymmetrical relationship which might discourage tutees' initiative-taking in the group (Rogat & Adams-Wiggins, 2014; Webb, Ing, Kersting, & Nemer, 2006). On the other hand, tutors and tutees in a same-age peer tutoring format are assumed to demonstrate comparable levels of expertise and development (Falchikov, 2001; Fantuzzo, King, & Heller, 1992; Topping, 1996). Consequently, the student taking the tutor role might be perceived more easily as a true peer, who shares responsibility for productive collaborative learning with tutees (Colvin, 2007; Robinson et al., 2005). In order to be successful, same-age peer tutors should, however, be provided with additional information, tools, or resources to assure they sufficiently master subject knowledge and are skilled enough to cognitively challenge tutees' understanding (Falchikov, 2001; Topping, 2005).

Based on the level of role continuity a distinction can further be made between fixed versus reciprocal peer tutoring (Duran & Monereo, 2005; Falchikov, 2001; Griffin & Griffin, 1998; Topping, 1996). During fixed peer tutoring, students operate as either tutor or tutee for the complete duration of a peer tutoring intervention, without alternating roles. Especially cross-age peer tutoring settings are frequently characterised by fixed role taking (Duran & Monereo, 2005; Topping, 2005). Alternatively, reciprocal peer tutoring is characterised by the structured exchange of the tutor role among peer tutoring participants (Cheng & Ku, 2007; Fantuzzo et al., 1992; Ginsburg-Block & Fantuzzo, 1997; Griffin & Griffin, 1998). It consequently enables each participant to alternate between and experience both the specific benefits and challenges of providing (i.e. in the tutor role) and receiving (i.e. in the tutee role) academic support. Reciprocal peer tutoring is mostly associated

[2] Given that differences in students' age are closely related to differences in aptitude and skills, "same-/cross-age" in the present dissertation can be interpreted as "same-/cross-ability".

with same-age settings (Falchikov, 2001; Topping, 2005). In line with cross-age versus same-age peer tutoring, fixed versus reciprocal peer tutoring each give rise to distinct social dynamics, which are guided by and simultaneously give direction to peer tutors' and tutees' social status, students' perceptions of tutor versus tutee responsibilities, as well as students' initiative for learning and regulation (Cheng & Ku, 2007; Duran & Monereo, 2005; Robinson et al., 2005; Topping, 1996).

Theoretical perspectives on the value of social interaction

Successful peer tutoring requires students to discuss and agree upon both the content and the organisation of their collaborative learning. In other words, peer tutoring is to be interpreted primarily as a social process, in which peer interactions and discussions are situated as core elements (Chi et al., 2001; King et al., 1998; Roscoe, 2014; Topping, 1996). Despite general acknowledgement that communication and social interaction are essential for students' development of knowledge and understanding, the underlying mechanisms responsible for the effectiveness of peer learning are often derived and explained from different theoretical perspectives.

From a *cognitive perspective*, learning is conceptualised as cognitive change, implying a learner's knowledge is reorganised and reconstructed as new and prior knowledge are connected and this connection is integrated in the learner's existing knowledge base (Falchikov, 2001; King et al., 1998; Mercer, 1996). From a socio-cognitive perspective, such cognitive changes are assumed to be strongly influenced and fostered by social interaction (Iiskala et al., 2011; King, 1998; Webb & Mastergeorge, 2003). Piaget stressed that interaction with peers helps the learner to become sensitive for peers' understanding of information and events, which in its turn is likely to transform the learner's understanding (Falchikov, 2001; Mercer, 1996). By explicating and clarifying one's reasoning to peers, conceptual discrepancies or socio-cognitive conflicts arise when differences in peers' reasoning are exposed (King et al., 1998; Volet et al., 2009b). In an attempt to comprehend each other and to solve these socio-cognitive conflicts, peers are expected to mutually negotiate their initially contrasting understanding in subsequent interactions, eliciting shared meaning and the co-construction of new knowledge (Iiskala et al., 2011; King, 1998; Webb & Mastergeorge, 2003).

On the other hand, Vygotsky's *socio-cultural theory* emphasises cooperation rather than conflict, suggesting that cognitive development demands for social interaction through problem solving in collaboration with a more capable other (e.g. peer or adult) (Falchikov, 2001; Hadwin et al., 2005; Mercer, 1996). More specifically, Vygotsky (1978) stressed the transition from interpersonal to intrapersonal knowledge and competence, arguing that social interaction during preceding learning is to be considered a precondition for the learner's independent acquisition of knowledge and skills in subsequent learning. Verbal mediation during social interaction with peers not only prompts the learner to modify his reasoning and knowledge structures, but also encourages him to internalise jointly constructed meaning (King et al., 1998; Mercer, 1996; Roscoe & Chi, 2008). In other words, generating a transition from knowledge and skills demonstrated at the interpersonal level towards an intrapersonal level. It should be noted, however, that a successful transition requires peers to cognitively challenge the learner within his "zone of proximal development" (ZPD) (Chi et al., 2001;

Hadwin et al., 2005; Iiskala et al., 2011; King et al., 1998). The latter refers to the distance between what the learner could accomplish independently and a higher mastery level, which could be accomplished when guided by a more capable other (Mercer, 1996; Topping, 2005; Volet et al., 2009b). Verbal mediation within a learner's ZPD promotes meaningful learning since it enables the learner to bridge the gap between his actual and his potential competence (Hadwin et al., 2005; King et al., 1998; Roscoe & Chi, 2008; Webb & Mastergeorge, 2003). From a socio-cultural perspective, cognitive development is therefore conceptualised as a learner's gradual shift towards a next ZPD, based on the internalisation of knowledge and skills demonstrated and negotiated during social interaction (Chi et al., 2001; Hadwin et al., 2005; Hurme et al., 2006; Webb & Mastergeorge, 2003).

Although both theoretical frameworks explain the effectiveness of social interaction for learning differently, they are not incompatible with each other. In contrast, by emphasising the importance of different processes during interactive and collaborative learning, both theories help us to obtain a more complete understanding of the strength of social interaction and peer discussion.

Peer tutoring as an effective instructional approach

Previous research provided empirical support about the positive effects of peer tutoring in diverse instructional settings with various student populations, ranging from performance-related and cognitive gains over social-motivational benefits, to metacognitive effects, for both peer tutors and tutees (Falchikov, 2001; Topping, 2005). Peer tutoring participants generally demonstrate better performance and higher academic achievement (Rohrbeck, Ginsburg-Block, Fantuzzo, & Miller, 2003; Topping, Campbell, Douglas, & Smith, 2003), which is often related to improved understanding of the learning content (Cohen, Kulik, & Kulik, 1982; Griffin & Griffin, 1998; Ritschoff & Griffin, 2001), more frequent higher-order thinking (King et al., 1998; Roscoe & Chi, 2008; Topping & Bryce, 2004), increased transfer of learning (Falchikov, 2001), as well as more profound knowledge-construction after applying more deep and strategic learning strategies (Ashwin, 2003; King et al., 1998; Topping et al., 2003). Peer tutoring settings are perceived by students as safe learning environments, stimulating tutors' and tutees' self-confidence and lowering their distress (Cheng & Ku, 2007; Fantuzzo, Riggio, Connelly, & Dimeff, 1989). Additionally, peer tutoring appears to result in positive attitudes towards school and the subject matter, as well as in increased academic satisfaction (Cohen et al., 1982; Fantuzzo et al., 1989; Robinson et al., 2005). Peer tutoring participants further report improved social and communication behaviour (Ashwin, 2003; Topping et al., 2003). Although positive effects on students' self-efficacy have been revealed (e.g. Cohen et al., 1982; Fantuzzo et al., 1989), these could not always be confirmed in other studies (e.g. Ritschoff & Griffin, 2001; van Dinther, Dochy, & Segers, 2010). In contrast, research is clear about students' appreciation for peer tutoring, both when providing and when receiving academic help from peers (Ginsburg-Block & Fantuzzo, 1997; Griffin & Griffin, 1998; Topping & Bryce, 2004).

Regarding the effects of peer tutoring on students' metacognition, empirical research showed that peer tutors' and tutees' dialogues frequently trigger metacognitive processes (King et al., 1998; Roscoe, 2014), resulting in increased metacognitive knowledge (Shamir, Zion, & Spector-Levi, 2008), enhanced self-regulated learning (King, 1998; Shamir & Tzuriel, 2004), and higher levels of self-control (Fantuzzo et al., 1992). Collaborative learning through peer tutoring particularly appears to foster peer tutors and tutees to monitor their comprehension (King, 1998; Roscoe, 2014; Roscoe & Chi, 2008). Although it seems plausible that collective problem solving in peer tutoring groups might also promote students' engagement in other regulation skills (i.e. orientation, planning, and evaluation), as well as their adoption of social forms of regulation (i.e. co-regulation and SSMR), empirical research in this respect is currently not available.

The importance of high-quality peer discussions

The open learning environment established in a peer tutoring setting provides tutors and tutees with a platform to adopt, train, and refine diverse learning and regulation strategies, often benefitting their learning outcomes (Goos et al., 2002; King, 1998; Roscoe, 2014; Volet et al., 2009b). Nevertheless, bringing students together during peer tutoring cannot guarantee productive learning and regulation (Barron, 2003; Dillenbourg, 1999). In contrast, the success of peer tutoring is often conditional upon the underlying group dynamics and process-oriented particularities of peers' discussions and interactions, often invoked by explicit instructional interventions (Hurme et al., 2006; Pata et al., 2005; Roscoe & Chi, 2007; Topping, 1996; Webb et al., 2006). More specifically, peer tutors' and tutees' engagement in questioning and explaining aimed at processing and co-constructing knowledge, as well as the level of reciprocity in students' interactive discussions appear to be decisive for peer tutors' and tutees' meaningful learning (Chi et al., 2001; Goos et al., 2002; Graesser & Person, 1994; King et al., 1998; Roscoe, 2014; Teasley, 1997). The latter emphasises the importance of adequate instructional set-ups to invoke these high-level peer discussions.

Learning through questioning and explaining

Questioning and explaining are fundamental sources for learning during peer tutoring (Graesser & Person, 1994; King, 1998; Roscoe & Chi, 2007; Webb et al., 2006). Peer tutors are expected to provide explanations to convey knowledge and to make information comprehensible, in order to stimulate tutees' conceptual understanding (King et al., 1998; Roscoe & Chi, 2008; Teasley, 1997). Additionally, tutees often seek peers' help by engaging in self-explaining, verbalising their reasoning in order to receive peers' confirmative or corrective feedback on their explained understanding (Chi et al., 2001; Graesser & Person, 1994; Webb & Mastergeorge, 2003). Research demonstrated that tutorial dialogues are predominantly characterised by the peer tutor explaining core topics and relationships between knowledge components to tutees, aimed at either introducing new information or at correcting tutees' misconceptions (Graesser & Person, 1994; King, 1998; Roscoe & Chi, 2008). Despite differences in peer tutors' and tutees' expertise and domain-specific knowledge, peer tutors cannot be considered expert instructors (Chi et al., 2001; Topping, 2005). Ensuring explanations which are relevant, coherent, and accurate therefore requires peer tutors to permanently monitor their own understanding (Falchikov, 2001; King et al., 1998; Roscoe, 2014).

Explaining often results from questioning and simultaneously provides input to stimulate the latter (Barron, 2003; Chi et al., 2001; Webb et al., 2006). Given that questioning prompts learners to reflect and optimise their thinking (King et al., 1998; Roscoe, 2014) and that peer tutors in general engage more frequently in questioning compared to teachers in traditional classrooms (Graesser & Person, 1994), peer tutoring could be valuable to foster students' learning. Peer tutors ask questions to activate tutees' prior knowledge when introducing new information, to guide and assess tutees' understanding, and to inquire about the group's progress (Graesser & Person, 1994; King et al., 1998; Roscoe & Chi, 2007). Similarly, tutees ask for clarification after conceptual confusion, for additional information when integrating new and prior knowledge, and for evaluation of interpretations or proposed problem solving strategies (Chi et al., 2001; Graesser & Person, 1998; King et al., 1998; Webb et al., 2006).

Given that questioning and explaining elicit the mutual exchange of ideas, invoking cognitive restructuring and reflection on one's own and each other's learning, both might have the potential to elicit meaningful learning as well as students' engagement in metacognitive regulation (King, 1998; Rogat & Linnenbrink-Garcia, 2011; Volet et al., 2009a). More specifically, thought-provoking questioning or knowledge-building explaining, aimed at integrating, justifying, and elaborating on information (Graesser & Person, 1994; Roscoe & Chi, 2008), is assumed to encourage the revision of mental models and collaborative learning strategies, directly addressing students' metacognitive regulation (Rogat & Linnenbrink-Garcia, 2011; Volet et al., 2009a). In contrast, factual questions and knowledge-reviewing explanations (Graesser & Person, 1994; Roscoe & Chi, 2007) might evoke less cognitive restructuring and consequently less metacognitive regulation (King, 1998; Rogat & Linnenbrink-Garcia, 2011; Volet et al., 2009b).

Peer tutors' and tutees' mutual engagement in transactive discussions

Co-constructing knowledge and sharing meaning through reflection on one's own and collaborating peers' understanding, requires qualitative interactions in which peer tutoring participants mutually react on each other's contributions, eliciting sequences of reciprocal conversational exchanges (Goos et al., 2002; Hurme et al., 2006; Teasley, 1997). The current dissertation refers to students' reciprocal contributions to the peer tutoring interactions as transactive discussions (King, 1998; Weinberger, Stegmann, & Fischer, 2007). Transactivity is more specifically conceptualised as a conversational mode in which students' statements operate on previously expressed reasoning of each other (other-oriented) or themselves (self-oriented) (Berkowitz, Althof, Turner, & Bloch, 2008; Teasley, 1997). Depending on the level of elaboration in a student's reaction to a collaborating peer's initial action, a distinction is made between for example representational and operational transactive discussions (Berkowitz et al., 2008). Representational (i.e. low transactive) discussions, in which students' contributions merely represent previously articulated statements, appear to hamper learning (Webb et al., 2006; Weinberger et al., 2007). In contrast, operational (i.e. highly transactive) discussions, characterised by conversational connectedness and elaborative transformation of peers' thinking, are positively correlated to students' reasoning and active knowledge construction (Berkowitz et al., 2008; Teasley, 1997; Weinberger et al., 2007). Although it seems plausible that operational discussions can facilitate students' adoption of metacognitive regulation, the relation between collaborative learners' transactive discussions and their engagement in particular metacognitive regulation behaviour, is empirically underexposed.

Need for explicit instruction and support

Although students' adoption of higher-order questioning and explaining, as well as highly interactive discussions aimed at actively transforming each other's reasoning, foster meaningful learning, peer tutoring participants' spontaneous engagement in such interactions is often insufficient. Empirical research demonstrated that (particularly untrained) peer tutors' explanations and questions are often shallow, focussed on delivering knowledge in lengthy explanations and verifying tutees' comprehension with closed questions (e.g. "do you understand?") (Chi et al., 2001; Graesser & Person, 1994; King, 1998; Roscoe & Chi, 2007). Since peer tutors' actions influence tutees' reactions (Roscoe & Chi, 2008), tutees often respond with additional reviewing or confirmation questions, and paraphrasing explanations (Chi et al., 2001; King et al., 1998; Webb & Mastergeorge, 2003). Moreover, peer tutors tend to monopolise the tutorial dialogues, leaving limited space for tutees' contributions and truly interactive conceptual discussions (Chi et al., 2001). Consequently, maximising the academic benefits of peer tutoring demands for preliminary training (Falchikov, 2001; Roscoe & Chi, 2007; Topping, 1996). Peer tutors should be trained to challenge tutees' understanding with elaborative explanations and reflective inquiries, aimed at stimulating tutees' deep reasoning (Graesser & Person, 1994; King et al., 1998; Roscoe & Chi, 2008; Webb et al., 2006), as well as to scaffold tutees' learning appropriately, encouraging tutees to share their understanding in interactive discussions (Azevedo & Hadwin, 2005; Chi et al., 2001; Molenaar et al., 2014). Peer tutors and tutees should further be instructed about and encouraged to practice social, communicative, and metacognitive skills, aimed at generating and regulating productive collaborative learning (Barron, 2003; Topping, 2005). Additionally, peer tutoring participants should receive ongoing support stimulating them to reflect upon and optimise their role taking (Falchikov, 2001; Schraw et al., 2006; Topping, 1996). Productive peer tutoring further demands for the design of specific learning materials, which structure peers' learning up to some extent, set specific learning objectives, and encourage collaboration and cognitive processing (Falchikov, 2001; King, 1998; Topping, 1996).

As a conclusion

Although academic success in higher education can be advanced by students' competence to self-regulate their learning, their regulation skills are often insufficient, revealing a need to design, implement, and evaluate initiatives fostering higher education students' metacognitive regulation (MacLellan & Soden, 2006; Nota et al., 2004; Veenman et al., 2006). In this respect, there are promising indications that collaborative learning can facilitate and optimise students' adoption of metacognitive regulation (Hadwin et al., 2011; Iiskala et al., 2011; Volet et al., 2009a). It moreover challenges students to share metacognitive regulation at an interpersonal level, which is assumed to enhance both individual students' and the collaborative learning group's learning (Grau & Whitebread, 2012; Järvelä et al., 2013; Volet et al., 2013). To date, it remains, nevertheless, unclear which underlying processes or interaction mechanisms evoke collaborative learners' involvement in particular metacognitive regulation behaviour, as previous research on metacognitive regulation in social settings is mainly output-related (Molenaar & Järvelä, 2014; Roscoe, 2014; Vauras & Volet, 2013; Veenman et al., 2006). Unravelling the interactional dynamics between collaborative learners is, however, necessary to comprehend and optimise collaborative learning's metacognitive potential (Molenaar & Järvelä, 2014; Roscoe, 2014). The present dissertation therefore aims at examining and clarifying why peer tutoring, as a specific type of collaborative learning, can be valuable to foster higher education students' adoption of (social forms of) metacognitive regulation, taking into account process-oriented measures of students' collaborative learning. The studies included in the present dissertation are more specifically organised according to four general research lines, which will be discussed in the next paragraphs.

Four lines of research

Although the metacognitive benefits of peer tutoring are widely accepted and its impact on students' monitoring, in particular, empirically validated (King et al., 1998; Roscoe, 2014; Shamir & Tzuriel, 2004), many questions regarding peer tutoring participants' adoption of metacognitive regulation remain unanswered. In general, the following major challenges for research can be delineated from the trends in the literature on metacognition and on peer tutoring, discussed above. There is a need to identify successful instructional initiatives fostering higher education students' metacognitive regulation (MacLellan & Soden, 2006; Nota et al., 2004; Perry & Winne, 2013). Additionally, there is a call for taking an integrative perspective on metacognitive regulation when evaluating the impact of initiatives promoting students' regulation. More specifically, all key regulation skills (i.e. orientation, planning, monitoring, and evaluation), as well as differences in the quality of adopted metacognitive regulation behaviour should be taken into account (Järvelä et al., 2013; Rogat & Linnenbrink-Garcia, 2011; Zimmerman & Schunk, 2011). Further, there is a need for research on social forms of metacognitive regulation, in particular SSMR (Iiskala et al., 2011; Rogat & Adams-Wiggins, 2014; Vauras & Volet, 2013). In addition, there is a call for process-oriented investigations of peer tutoring, aimed at explaining which characteristics of the collaborative learning process particularly contribute to the metacognitive effectiveness of peer tutoring (Roscoe, 2014). Last, there is a call for in-depth process-oriented analysis of peer tutors' and tutees' interactions in order to provide group-related measures of collaborative learners' adoption of metacognitive regulation (Molenaar & Järvelä, 2014; Perry & Winne, 2013; Volet et al., 2013). The present dissertation aims at contributing to these perceived gaps in the literature on metacognitive regulation in collaborative learning settings by transforming the abovementioned challenges into four research lines, which are each guided by two more specific research objectives. The relation between the research lines and research objectives is clarified in more detail in the paragraph "Overview of the dissertation" (see p. 26). The following four research lines tackle the challenges described above, aimed at studying:

(1) the impact of reciprocal peer tutoring (RPT) on individual students' metacognitive regulation;
(2) the impact of RPT on RPT-groups' metacognitive regulation;
(3) the impact of metacognitive scaffolds on RPT-groups' adoption of metacognitive regulation;
(4) the correlates of RPT-groups' metacognitive regulation.

Research line 1 (RL1) focusses on investigating the impact of participation in RPT on individual RPT-participants' adoption of metacognitive regulation. This research line is delineated from the challenges to identify successful initiatives promoting students' regulation and to take an integrative perspective on metacognitive regulation. Within RL1, the following two research objectives (RO) are put forward:

RO 1.1: studying the impact of RPT on individual students' metacognitive knowledge, perceived adoption of key regulation skills, and actual adoption of key regulation skills;

RO 1.2: studying the impact of RPT on individual students' actual adoption of key regulation skills and deep-level approach to metacognitive regulation.

In addition to the focus on individual RPT-participants' adoption of metacognitive regulation in RL1, research line 2 (RL2) studies the impact of RPT on the adoption of metacognitive regulation by RPT-groups. This second research line is derived from the challenges to identify successful initiatives promoting students' regulation, to take an integrative perspective on metacognitive regulation, to study social forms of metacognitive regulation, as well as to provide process-oriented, group-related measures on collaborative learners' metacognitive regulation. The following two research objectives are studied:

RO 2.1: unravelling time-bound evolutions in the frequency of occurrence of RPT-groups' adoption of key regulation skills, in their engagement in deep-level metacognitive regulation, as well as in tutees' initiative for metacognitive regulation;

RO 2.2: unravelling time-bound evolutions in RPT-groups' adoption of individually-oriented metacognitive regulation, co-regulation, and socially shared metacognitive regulation (SSMR).

Research line 3 (RL3) focusses on the impact of metacognitive scaffolds on RPT-groups' adoption of metacognitive regulation. RL3 is derived from the challenges to identify successful initiatives promoting students' regulation, to take an integrative perspective on metacognitive regulation, to study social forms of metacognitive regulation, as well as to provide process-oriented, group-related measures on collaborative learners' metacognitive regulation. Within the third research line, the following two research objectives are put forward:

RO 3.1: investigating the impact of different scaffold types (i.e. structuring versus problematising scaffolds) on RPT-groups' adoption of key regulation skills, deep-level regulation approach, and tutee-initiated metacognitive regulation;

RO 3.2: investigating the impact of different scaffold types (i.e. structuring versus problematising scaffolds) on RPT-groups' adoption of co-regulation and SSMR.

Research line 4 (RL4) studies the correlates of RPT-groups' adopted metacognitive regulation. It is delineated from the challenges to explain which particularities of peer tutors' and tutees' interactions contribute to the metacognitive potential of peer tutoring, to take an integrative perspective on metacognitive regulation, and to study social forms of metacognitive regulation. Within the fourth research line, the following two research objectives are distinguished:

RO 4.1: examining the relationship of RPT-groups' adoption of key regulation skills and deep-level regulation approach with their content processing strategies and transactive discussions;

RO 4.2: examining the relationship of RPT-groups' adoption of SSMR with their content processing strategies and transactive discussions.

Design of the studies

Educational research is characterised by a dominance of quantitative research, consisting of collecting precise and numerical data in large samples of participants, and subsequently statistically analysing these quantifiable data in an objective manner (Creswell, 2008; Koul, 2009). Nevertheless, the past decades the value of qualitative research has been increasingly acknowledged, particularly in research on metacognition, given that quantitative (i.e. predominantly off-line) measures appeared to provide inaccurate data on students' actual metacognitive regulation behaviour (Azevedo, 2009; Ericsson & Simon, 1993; Miles & Huberman, 1994; Veenman et al., 2006). Qualitative research allows for in-depth analysis of dynamic processes and a more comprehensive understanding of participants' behaviour and interpretations, situated and embedded in a specific context (Miles & Huberman, 1994; Vauras & Volet, 2013). It requires the development of reliable and valid coding instruments, as well as rigorous observation, coding, and interpretation of participants' behaviour or words, which is rather time-and labour-intensive and can therefore only be applied to a limited sample of participants (Creswell, 2008; Miles & Huberman, 1994). In the current literature on metacognition, there is a clear call for more qualitative or mixed model approaches in order to grasp a better understanding of complex processes such as metacognitively regulating one's learning or socially sharing metacognitive regulation (Tashakkori & Creswell, 2007; Vauras & Volet, 2013; Veenman, 2011). Therefore, the empirical studies entailed in the present dissertation mainly reflect a qualitative research approach, characterised by the collection of concurrent data on participants' metacognitive regulation, derived from participants' words (e.g. in think-aloud protocols or verbalised interaction during videotaped tutorial dialogues) and by subsequent transformation of these qualitative data into numerical scores which are analysed statistically (Koul, 2009; Tashakkori & Creswell, 2007). The latter allows a rigorous testing of hypotheses.

In order to achieve the research objectives outlined above, eight empirical studies were set up, that are descriptive and quasi-experimental in nature. Descriptive research applies methods which allow description and interpretation of the present state of a learning context or the actual behaviour of a participant. On the other hand, quasi-experimental research is directed at studying the impact of an intervention in naturally constituted groups of participants, who are assigned to either an experimental or control condition (Creswell, 2008; Koul, 2009). To increase research validity, methodological triangulation is adopted, combining self-reports, think-aloud protocols, and video-based observation of participants' learning and metacognitive regulation behaviour, which are collected both at the level of individual participants and at the level of the RPT-groups.

Research setting: A higher education same-age RPT-intervention

For each of the empirical studies included in the present dissertation, a reciprocal peer tutoring intervention was implemented. We opted for same-age RPT because it was assumed to be a fruitful learning environment to adopt, foster, and refine students' metacognitive regulation. The small-scale setting of RPT not only allows for intensive metacognitive modelling by a more knowledgeable peer tutor, its rotating system of assigning the tutor role among collaborative learners was also assumed to prevent peer tutors from being too directive in regulating the group's learning (Hadwin et al., 2005; King, 1997; Rogat & Linnenbrink-Garcia, 2011). By requiring students to alternate between the tutor and tutee role, RPT-participants were expected to attribute more or less equal social status to both roles (Falchikov, 2001; Robinson et al., 2005; Webb & Mastergeorge, 2003), which was in its turn assumed to facilitate tutees' regulative contributions as well as to foster SSMR.

The RPT-intervention was implemented in an authentic higher education context at Ghent University (Flanders, Belgium). It concerned a formal component of the 5-credit course "Instructional Sciences" as part of the curriculum of students in the Educational Sciences programme who already obtained a Professional Bachelor degree. The intervention consisted of eight successive face-to-face sessions (including a training session), each taking two hours, and focussed on deepening students' understanding of learning contents that were previously addressed in theoretical lectures. Students were randomly assigned to small and stable RPT-groups of six. The tutor role was randomly appointed to students by a university staff member and interchanged at each session within each RPT-group. During each RPT-session, the tutor was primarily responsible for managing peers' interactions and stimulating collaborative learning, whereas tutees were expected to solve the group assignment. All RPT-groups were observed weekly by a university staff member to check whether RPT-participants enacted their tutor and tutee roles adequately.

During each RPT-session, students worked on authentic *group assignments*, related to content-specific themes of the course "Instructional Sciences". The assignments were presented as open-ended tasks, requiring students' collaboration and high levels of cognitive processing. Each assignment consisted of an outline of learning objectives, a subtask to get familiar with theme-specific terminology, and a subtask to apply theory to real-life cases. Despite differences in the central topic, all assignments addressed comparable learning experiences during each RPT-session.

All students participated in a compulsory and interactive *tutor training*, one week before the onset of the RPT-intervention. During this training, they were informed about the multidimensional responsibilities of the peer tutor and were taught a mix of generic tutoring skills. The focus was more specifically on establishing a safe learning climate, managing and stimulating interactions, asking differentiated questions, giving constructive feedback, providing comprehensive explanations, and scaffolding tutees' learning (Chi et al., 2001; Falchikov, 2001; King, 1998; Roscoe & Chi, 2007; Topping, 2005; Webb et al., 2006). The tutor training was summarised in a manual provided to each tutor.

To prepare themselves, peer tutors received a *session-specific "tutor guide"* one week in advance. This guide offered additional information about the theory to focus upon in the RPT-session and inspired students to tackle the problem solving process stepwise, by offering examples to explore task demands, develop actions plans, verify whether task requirements are met, and reflect on the RPT-session. These problem solving steps were depicted in a schematic overview, provided to each tutor. Although the theoretical content of the tutor guide differed across sessions, its structure and design were identical throughout the RPT-intervention.

To provide student support, *interim supervision sessions* and *feedback sessions* were organised. Halfway through the RPT-intervention, compulsory supervision sessions were organised for all students, encouraging them to reflect on their tutor and tutee role taking. Additionally, a university staff member provided group-specific feedback every two weeks, focusing on group dynamics, peer collaboration, equal contribution of tutees, and students' tutoring approach.

The abovementioned RPT-intervention was implemented during diverse academic years. Each implemented RPT-intervention was moreover linked to one or more empirical studies regarding the metacognitive regulation behaviour of RPT-participants (see Table 2). The following paragraphs provide an overview of the general structure of the present dissertation, including information on the design of each conducted empirical study.

Table 2. *Overview of the implementation sequence of the RPT-intervention in relation to the conducted studies*

Implementation sequence	Academic year	Connected empirical study
first implementation of the RPT-intervention	2009 – 2010	chapter 2
second implementation of the RPT-intervention	2010 – 2011	chapter 3
		chapter 4 and 5
		chapter 8 and 9
third implementation of the RPT-intervention	2012 – 2013	chapter 6 and 7

Overview of the dissertation

This dissertation includes ten chapters of which eight (chapter 2 to chapter 9) report on the findings of the empirical studies. Except for this introductory (chapter 1) and the concluding chapter (chapter 10), all chapters are based on articles published or submitted/under review for publication in international peer-reviewed journals, listed in the Social Science Citation Index. Table 3 provides an overview of the research lines, chapters, research objectives, research designs and samples, data collection and data analysis techniques in the different studies. Figure 4 additionally depicts the structure of this dissertation and positions the studies within the research lines. Chapter 2 and 3 fit in the first research line, directed at examining the impact of participation in RPT on individual participants' metacognitive regulation. Chapter 4 and 5 represent the second research line, focussed on investigating the impact of RPT on RPT-groups' adoption of metacognitive regulation. The first and second research line are to be situated as an initial step in studying the metacognitive potential of RPT, aimed at unravelling whether participation in RPT benefits individual students' or collaborative learning groups' involvement in particular metacognitive regulation behaviour. Chapter 6 and 7 fit in the third research line, directed at investigating the impact of metacognitive scaffolds on RPT-groups' adoption of metacognitive regulation. This third research line consequently aims at studying whether RPT-groups' naturally occurring metacognitive regulation behaviour can be optimised by providing RPT-groups with metacognitive scaffolds. Finally, chapter 8 and 9 represent the fourth research line, which does not study RPT's impact but is directed at explaining why RPT can be considered a fruitful environment for adopting metacognitive regulation skills and which particularities of peer tutors' and tutees' interactions facilitate the elicitation of particular metacognitive regulation behaviour.

Chapter 1 gives a general introduction to the present dissertation, by elaborating the conceptual framework and the underlying assumptions of the dissertation. This introductory chapter elaborates on the conceptualisation of metacognition and its key components. It further addresses metacognitive regulation in collaborative learning settings, introducing social forms of metacognitive regulation. Chapter 1 further elaborates on peer tutoring and RPT in particular, the dynamic roles of peer tutors and tutees, and the importance of qualitative peer-led interactions. Based on the conceptual framework, challenges for research are formulated and translated into four important research lines. Furthermore, chapter 1 provides an overview of the design and empirical studies included in the present dissertation.

Chapter 2, *Exploring the potential impact of reciprocal peer tutoring on higher education students' metacognitive knowledge and regulation,* examines whether participation in RPT generates a positive influence on higher education students' metacognitive knowledge, as well as on their self-perceived and actual adoption of key regulation skills. Sixty-seven first-year students in the Educational Sciences programme who previously obtained a Professional Bachelor degree, participated in a semester-long RPT-intervention as part of the study. A multi-method pretest-posttest design was adopted to assess their metacognition before the start (i.e. October 2009) and upon completion (i.e. December 2009) of the RPT-intervention, combining the administration of a self-report questionnaire with think-aloud protocol analysis. All students completed the 'Metacognitive Awareness Inventory' (MAI – Schraw & Dennisson, 1994) in order to assess their metacognitive knowledge and perceived adoption of metacognitive regulation. Additionally, they individually performed a think aloud task in order to identify students' actual adoption of metacognitive regulation. After coding the verbal protocols, paired-samples t-tests were run to test for significant differences in the frequency of occurrence of students' metacognitive regulation skills at pretest, compared to posttest. Pretest and posttest scores on the MAI were also compared by means of paired-samples t-tests to investigate whether participation in RPT influenced students' metacognitive knowledge and perceived metacognitive regulation. This chapter is published in *Instructional Science.*

Chapter 3, *Promoting university students' metacognitive regulation through peer learning: The potential of reciprocal peer tutoring*, studies the metacognitive potential of RPT, taking into account the results and methodological limitations of chapter 2. Since self-report measures appeared to provide inaccurate data on students' metacognition, chapter 3 exclusively examines the impact of RPT on students' actual adoption of metacognitive regulation. Both the frequency of occurrence of key regulation skills and students' adoption of a deep-level regulation approach are studied. A quasi-experimental pretest-posttest design was adopted, involving an experimental and two control groups. The experimental group (EG) consisted of the complete population of first-year students Educational Sciences who already obtained a Professional Bachelor degree and participated in the RPT-intervention from October 2010 until December 2010 (n=64). The first control group (CG1) consisted of 24 freshmen in the Educational Sciences programme, whereas the second control group (CG2) consisted of 22 first-year students in the Social Welfare programme of the same faculty, who also attained a Professional Bachelor degree. Both at the start (October) and at the end (December) of the semester, the regulation skills of individual participants were assessed (n=51 in EG, n=24 in CG1, and n=22 in CG2) by means of think-aloud protocol analysis. To study the impact of RPT on students' use of metacognitive skills and on their deep-level approach to regulation, two-way mixed ANOVA's were performed. This chapter is published in *Higher Education.*

Chapter 4, *Examining evolutions in the adoption of metacognitive regulation in reciprocal peer tutoring groups,* aims at studying the regulative potential of RPT based on group-related measures of adopted metacognitive regulation throughout the RPT-intervention. In this respect, an evolution towards increased regulation demonstrated by the RPT-groups, is perceived as a positive impact of RPT. From October 2010 until December 2010, 64 first-year students in the Educational Sciences programme who obtained a Professional Bachelor degree participated in the RPT-intervention (the same students participated as the experimental group in the study presented in chapter 3). All RPT-sessions of five randomly selected RPT-groups were videotaped, resulting in 70 hours of video recordings. Apart from chapter 4, also chapter 5, 8, and 9 of the present dissertation report on analyses which are conducted on these collected video data. In each of these chapters, assessment of RPT-groups' metacognitive regulation behaviour is based on observation of peer tutors' and tutees' verbalised interactions during RPT. In this respect, a literature-based coding instrument 'RPT_MCR' (i.e. reciprocal peer tutoring groups' metacognitive regulation) was designed, which allows to rigorously code collaborative learners' adoption of key regulation skills as well as more concrete regulation strategies. Chapter 4 more specifically studies time-bound evolutions in the frequency of occurrence of RPT-groups' adoption of key regulation skills. It also investigates whether RPT-groups' involvement in low-level versus deep-level metacognitive regulation changes over time. Further, evolutions in RPT-groups' tutor- and tutee-initiated metacognitive regulation are examined. Mixed models for logistic regression analysis allowing change points are adopted to study the abovementioned evolutions over time. This chapter is published in *Metacognition and Learning*.

Chapter 5, *Exploring evolutions in reciprocal peer tutoring groups' socially shared metacognitive regulation and identifying its metacognitive correlates,* is related to chapter 4 given that it also focusses on time-bound evolutions in RPT-groups' metacognitive regulation behaviour. Chapter 5, however, more specifically investigates whether RPT-groups' demonstrated metacognitive regulation is individually-oriented, focussed on co-regulation of peers' learning, or rather socially shared among multiple students, as well as whether RPT-groups' regulative foci (i.e. individually-oriented, co-regulated, or socially shared) significantly change over time. The video data collected for the study reported in chapter 4, were again used to analyse the foci of RPT-groups' metacognitive regulation behaviour. Mixed models for logistic regression analysis allowing change points were adopted to study time-bound evolutions in RPT-groups' regulative foci. Additionally, chapter 5 investigates whether the adoption of particular regulation skills and approaches is related to RPT-groups' socially shared regulation focus. Binary logistic regression analyses were used to examine the relationship between RPT-groups' SSMR and their engagement in orientation, planning, monitoring, and evaluation on the one hand and their adoption of low-level versus deep-level regulation on the other hand. This chapter is published in *Learning and Instruction.*

Chapter 6, *Eliciting reciprocal peer tutoring groups' metacognitive regulation through structuring and problematising scaffolds,* is situated in the third research line, directed at optimising RPT-groups' spontaneously demonstrated metacognitive regulation. Based on the results of the study reported in chapter 4, the original RPT-intervention (implemented during the academic years 2009-2010 and 2010-2011) was modified in order to elicit a more balanced involvement of RPT-groups in all key regulation skills, as well as to increase both their engagement in deep-level regulation and tutees' initiative for regulating the RPT-groups' learning. More specifically, metacognitive scaffolds were included in the RPT-learning materials, encouraging RPT-participants to apply particular metacognitive regulation behaviour. Fifty-eight first-year Educational Sciences students who already obtained a Professional Bachelor degree participated in the revised RPT-intervention from October 2012 until December 2012. A quasi experimental design was adopted, involving two experimental conditions: a structuring scaffold (SS) condition, in which students were given direct guidelines to apply particular regulation skills, and a problematising scaffold (PS) condition, in which students were provided with reflection-provoking prompts encouraging them to critically address particular regulation skills. The first (at the start), third (halfway), and sixth (upon completion) RPT-session of eight randomly selected RPT-groups (i.e. four from the SS-condition and four from the PS-condition) were videotaped, resulting in 48 hours of video recordings. Assessment of RPT-groups' metacognitive regulation behaviour was based on observation of peer tutors' and tutees' verbalised interactions during the videotaped RPT-sessions, which were coded with the RPT_MCR instrument designed for the study in chapter 4. To investigate whether structuring and problematising scaffolds generated a differential impact on RPT-groups' adoption of particular regulation skills, involvement in deep-level regulation, and tutees' initiative for regulation, two-way mixed ANOVA's were performed. This chapter has been resubmitted for publication in *The Journal of Experimental Education,* after a second revision based on the reviewers' comments.

Chapter 7, *Eliciting co-regulation and socially-shared metacognitive regulation through structuring and problematising scaffolds,* is closely related to chapter 5 and 6 given that it reports on the impact of structuring versus problematising scaffolds on RPT-groups' adoption of social forms of metacognitive regulation. The results of the study presented in chapter 5 revealed that RPT-participants' adoption of social forms of metacognitive regulation, particularly tutee-prompted co-regulation and SSMR, could be optimised. Chapter 7 investigates whether providing RPT-groups with additional support by means of structuring (SS) or problematising scaffolds (PS) can increase the groups' engagement in social forms of metacognitive regulation. The analyses for this study are conducted on the video data which were originally collected for the empirical study presented in chapter 6. To investigate whether structuring and problematising scaffolds generated a differential impact on RPT-groups' adoption of tutor-prompted co-regulation, tutee-prompted co-regulation, and SSMR, Mann-Whitney U tests were run. Additionally, chapter 7 examines whether structuring and problematising scaffolds evoked other evolutions in RPT-groups adopting social forms of metacognitive regulation, by means of binary logistic regression analyses for each research condition. This chapter has been submitted for publication in *Cognition and Instruction.*

Chapter 8, *Metacognitive regulation during reciprocal peer tutoring: Examining its relationship with students' content processing and transactive discussions* is situated in the fourth research line, directed at explaining which characteristics of peer tutors' and tutees' interactions contribute to collaborative learners' engagement in metacognitive regulation. Chapter 8 more specifically investigates whether RPT-groups' content processing strategies (i.e. questioning and explaining) on the one hand, the level of transactivity in their peer discussions on the other hand, are significantly related to RPT-groups' adoption of particular regulation skills as well as to their involvement in deep-level metacognitive regulation. The data for this study were collected during the implementation of a RPT-intervention from October 2010 until December 2010, as part of the empirical study presented in chapter 4. All RPT-sessions of five randomly selected RPT-groups were videotaped. RPT-groups' metacognitive regulation behaviour was coded with the RPT_MCR instrument, originally developed for the study which is presented in chapter 4. Additionally, literature-based coding instruments which allowed the identification of RPT-groups' questioning and explaining (i.e. RPT_CON: reciprocal peer tutoring groups' content processing), as well as the level of transactivity in their peer discussions (i.e. RPT_TRANS: reciprocal peer tutoring groups' transactive discussions) were developed. All assessments were based on the observation of peer tutors' and tutees' verbalised interactions. Binary logistic regression analyses were performed to investigate whether RPT-groups' adoption of key regulation skills and deep-level regulation approach was significantly correlated with their content processing strategies and the level of transactivity in their peer discussions. This chapter has been submitted for publication in *Higher Education.*

Chapter 9, *Socially shared metacognitive regulation during reciprocal peer tutoring: Identifying its relationship with students' content processing and transactive discussions* concerns the second chapter in the research line on identifying correlates of RPT-groups' metacognitive regulation behaviour. It more specifically focusses on predicting RPT-groups' engagement in SSMR based on their adoption of particular content processing strategies (i.e. questioning and explaining) and the level of transactivity in peer tutors' and tutees' interactions. The analyses for this study are conducted on the video data which were originally collected for the empirical study presented in chapter 4, derived from five randomly selected RPT-groups (i.e. 70 hours of video recordings). RPT-groups' SSMR, content processing, and transactive discussions were coded by means of the instruments RPT_MCR, RPT_CON, and RPT_TRANS, respectively, designed for the studies reported in chapter 5 and chapter 8. All assessments were based on peer tutors' and tutees' verbalised interaction. Binary logistic regression analyses were performed to investigate whether RPT-groups' adoption of SSMR was significantly correlated with their content processing strategies and the level of transactivity in their peer discussions. This chapter is published in *Instructional Science.*

Chapter 10 concerns a concluding chapter in which the findings of all empirical studies presented in the previous chapters, are summarised and a general discussion of these findings in relation to the proposed research lines and research objectives is provided. Additionally, limitations of the conducted studies as well as possible directions for future research are discussed. Chapter 10 concludes with the contributions and implications of the present dissertation's findings for educational research and theory on the one hand, educational practice and policy on the other hand.

Table 3. *Overview of the research lines, chapters, research objectives, research designs and samples, data collection, and data analysis techniques*

Research line	**Chapter**	**Research objective**	**Research design and sample**	**Data collection**	**Data analysis techniques**
	1	General introduction (conceptual framework, research lines and objectives, research design, and overview of the dissertation)			
Research line 1	2	To study the impact of RPT on individual students' metacognitive knowledge, perceived and actual adoption of key regulation skills	Multi-method pretest-posttest design (*n*=67)	Student self-reports Think-aloud protocol analysis	Paired-samples t-test (SPSS)
	3	To study the impact of RPT on individual students' actual adoption of key regulation skills and a deep-level regulation approach	Quasi-experimental pretest-posttest design with 1 experimental (*n*=51) and 2 control groups (n_{CG1}=24; n_{CG2}=22)	Think-aloud protocol analysis	Two-way mixed analysis of variance (SPSS)
Research line 2	4	To unravel time-bound evolutions in the frequency of occurrence of RPT-groups' adoption of key regulation skills, their engagement in deep-level regulation, and tutees' initiative for metacognitive regulation	Repeated measures design (*n*=5 groups or 30 students)	Analysis of videotaped RPT-sessions	Mixed model logistic regression analysis allowing change points (R)
	5	To unravel time-bound evolutions in RPT-groups' adoption of individually-oriented metacognitive regulation, co-regulation, and SSMR	Repeated measures design (*n*=5 groups or 30 students)	Analysis of videotaped RPT-sessions	Mixed model logistic regression analysis allowing change points (R)
Research line 3	6	To investigate the differential impact of structuring versus problematising scaffolds on RPT-groups' adoption of key regulation skills, deep-level regulation, and tutee-initiated metacognitive regulation	Quasi-experimental repeated measures design with two experimental groups (n_{EG1} and n_{EG2}=4 groups or 24 students)	Analysis of videotaped RPT-sessions	Two-way mixed analysis of variance (SPSS)
	7	To investigate the differential impact of structuring versus problematising scaffolds on RPT-groups' adoption of co-regulation and SSMR	Quasi-experimental repeated measures design with two experimental groups (n_{EG1} and n_{EG2}=4 groups or 24 students)	Analysis of videotaped RPT-sessions	Mann Whitney U test (SPSS) Binary logistic regression analysis (SPSS)
Research line 4	8	To examine the relationship of RPT-groups' adoption of key regulation skills and deep-level regulation with their content processing strategies and transactive discussions	Correlational design (*n*= 5 groups or 30 students)	Analysis of videotaped RPT-sessions	Binary logistic regression analysis (SPSS)
	9	To examine the relationship of RPT-groups' adoption of SSMR with their content processing strategies and transactive discussions	Correlational design (*n*= 5 groups or 30 students)	Analysis of videotaped RPT-sessions	Binary logistic regression analysis (SPSS)
	10	General discussion and conclusion (overview of the main results, limitations and suggestions for future research, and implications of the dissertation)			

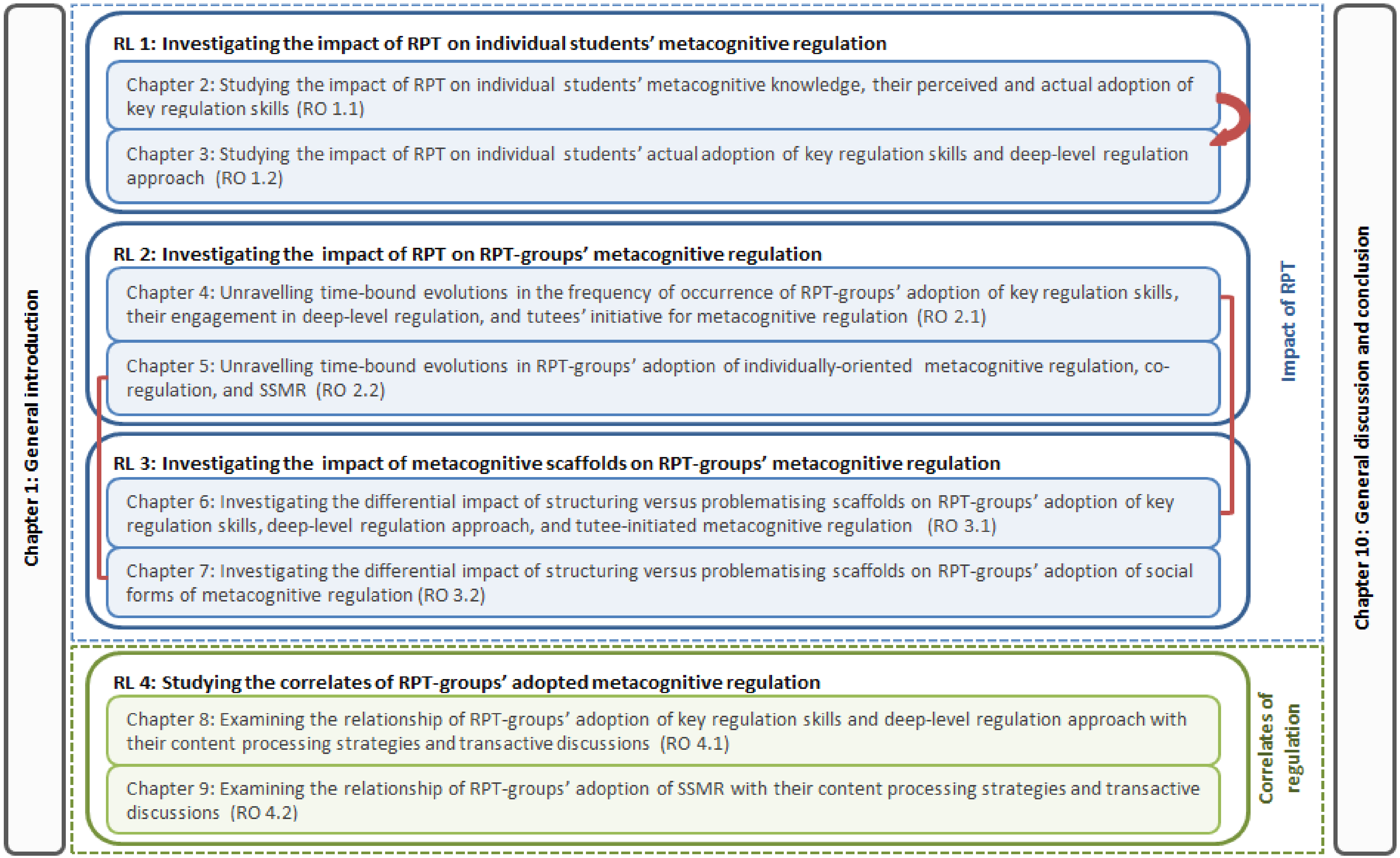

Figure 4. Overview of the studies in relation to the research lines (RL), research objectives (RO), and chapters of the dissertation

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2 Exploring the potential impact of reciprocal peer tutoring on higher education students' metacognitive knowledge and metacognitive regulation

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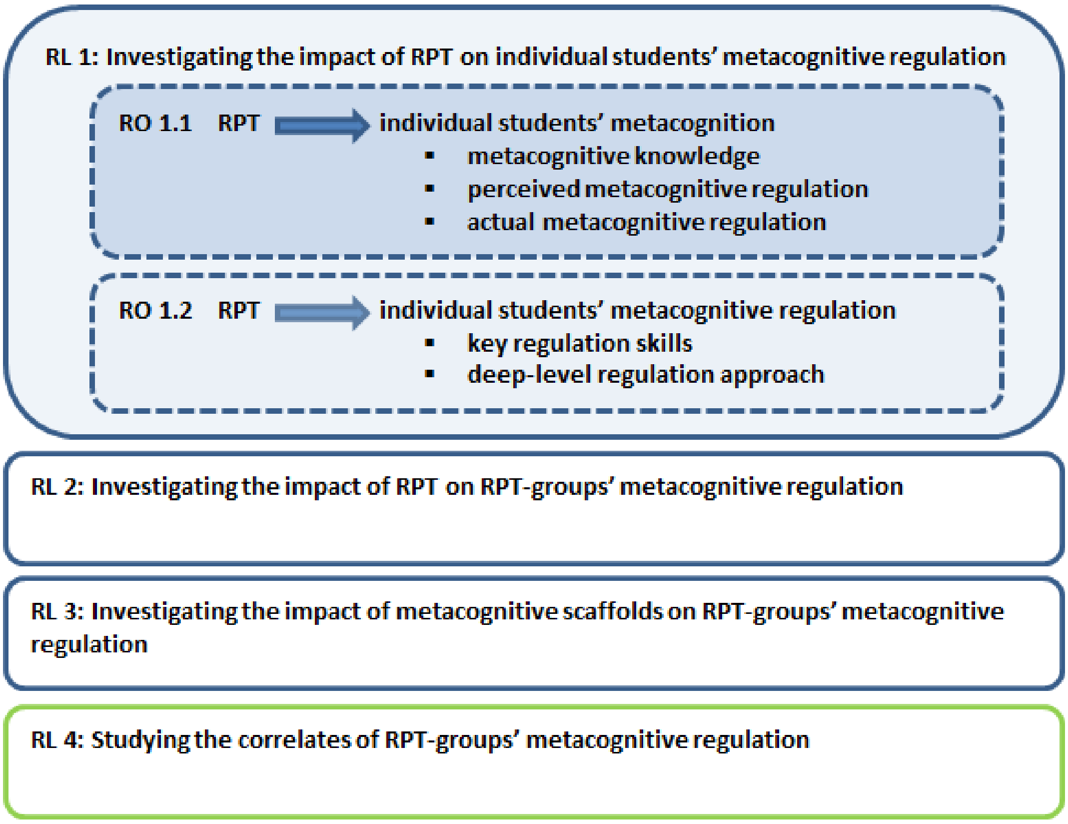

Figure 1. Chapter 2 in relation to the research lines of the dissertation

Chapter 2

Exploring the potential impact of reciprocal peer tutoring on higher education students' metacognitive knowledge and metacognitive regulation

Abstract

It is widely recognised that metacognition is an important mediator for successful and high-level learning, especially in higher education. Nevertheless, a majority of higher education students possess insufficient metacognitive knowledge and regulation skills to self-regulate their learning adequately. This study explores the potential of reciprocal peer tutoring (RPT) to promote both university students' metacognitive knowledge and their metacognitive regulation skills. The study was conducted in a naturalistic higher education setting, involving 67 students tutoring each other during a complete semester. A multi-method pretest-posttest design was used combining a self-report questionnaire, assessing students' metacognitive knowledge and their perceived metacognitive regulation, with the analysis of think-aloud protocols, revealing students' actual use of metacognitive regulation. Results indicate no significant pretest to posttest differences in students' metacognitive knowledge, nor in their perception of metacognitive skill use. In contrast, significant changes are observed in students' actual metacognitive regulation. At posttest, students demonstrate significantly more frequent and more varied use of metacognitive regulation, especially during the orientation, monitoring, and evaluation. Furthermore, our findings point at an increase in more profound and higher-quality strategy use at posttest.

Introduction

Contemporary education has shifted from a focus on knowledge transmission to knowledge construction, aiming at self-regulated and lifelong learning (Cornford, 2000). Central to self-regulated learning is the concept of metacognition (Efklides, 2008). Empirical evidence shows that metacognitive regulation corresponds with meaningful, deep-level learning and often results in higher achievement (e.g. Prins, Veenman, & Elshout, 2006; van der Stel & Veenman, 2010). Especially in higher education contexts, learners' metacognitive awareness and ability to regulate (meta)cognitive strategies are crucial to be successful (Cornford, 2002). However, only a few higher education programmes succeed in effectively preparing students for metacognitive self-regulation (MacLellan & Soden, 2006).

Recently, metacognition has been considered from the theoretical perspective of socially shared cognition, in which metacognition is conceptualised as a social activity that can be developed through interaction with teachers and/or other students (Hurme, Palonen, & Järvelä, 2006). The potential of collaborative learning to foster students' metacognitive development is currently highlighted (Iiskala, Vauras, Lehtinen & Salonen, 2011; Volet, Vauras, & Salonen, 2009). By regulating peers' learning and cognition, students question, reconstruct, and control their own cognitive processes and strategies. Empirical evidence exploring the influence of collaborative learning on higher education students' metacognitive development is, however, rather limited. The present study contributes towards filling this gap by exploring the potential of reciprocal peer tutoring, as a specific type of collaborative learning, to promote university students' metacognition.

Most research to date has either engaged in a theoretical discussion of the benefits of metacognition in general, or merely reported on the effects of metacognitive training on learning performance without assessing its influence on students' metacognitive activities (Veenman, van Hout-Wolters, & Afflerbach, 2006). In contrast to these studies, this research is concerned with the assessment of metacognitive behaviour as such. Moreover, the focus is not exclusively on either metacognitive knowledge (e.g. Antonietti, Ignazi, & Perego, 2000; Pintrich, 2002; Schraw, 1997) or metacognitive regulation skills (e.g. Bannert & Mengelkamp, 2008; Desoete, 2007; Moos & Azevedo, 2009; Veenman & Beishuizen, 2004), but on both components.

Theoretical framework

Metacognition

Metacognition refers to the ability to reflect upon, understand, manipulate, and regulate one's cognitive activities during learning (Efklides, 2008; Meijer, Veenman & van Hout-Wolters, 2006). In line with Brown's (1987) theoretical framework, we conceptualise metacognition as being comprised of two components: knowledge and regulation.

Metacognitive knowledge

Metacognitive knowledge refers to how much learners understand about the way people process information while engaged in academic tasks (Perfect & Schwartz, 2002). This kind of knowledge is relatively stable, expressible, fallible, and late-developing, because it requires learners to step back and to consider their own cognitive processes (Brown, 1987). Within metacognitive knowledge, declarative, procedural, and conditional knowledge can be distinguished (Schraw, 1998). Declarative knowledge concerns the insight into one's processing abilities and factors influencing one's performance. Procedural knowledge refers to knowledge of successful methods (heuristics and strategies) for achieving specific learning goals, and the awareness of how certain cognitive skills are to be employed in learning. Conditional knowledge concerns knowledge about the external conditions in which particular strategies are appropriate, including the reasons for their effectiveness.

Metacognitive regulation

Metacognitive regulation refers to skills used to orchestrate and oversee learning and performance (Efklides, 2008). In contrast to metacognitive knowledge, metacognitive regulation is assumed to be relatively unstable, difficult to express, and age-independent (Perfect & Schwartz, 2002). Brown (1987) distinguishes between planning, monitoring, and evaluation as the major skills before commencing an academic task, during task execution, and upon completion of the task, respectively. In line with Pressley (2000) and Veenman, Elshout, and Meijer (1997) a fourth metacognitive regulation skill can be added to this theoretical framework, namely orienting. Metacognitive orientation takes place prior to problem solving and aims at preparation of the sequential planning and execution of cognitive activities (Meijer et al., 2006; Veenman, Kok, & Blöte, 2005). The learner explores task demands and learning objectives, activates prior knowledge, and estimates task difficulty (Butler, 1998; Pressley, 2000). Related to orientation is metacognitive planning: thinking how, when, and why to anticipate during learning, resulting in the selection of appropriate strategies, the allocation of resources, and the development of an action plan to attain learning goals (Desoete, 2007; Veenman et al., 1997). When learners monitor their learning, they engage in on-line control of their cognitive strategies. Monitoring aims at the identification of inconsistencies and the modification of learning activities if needed (Meijer et al., 2006; Moos & Azevedo, 2009). Finally, evaluating involves learners' self-judging activities upon completion of a learning cycle (Veenman et al., 2005). These can be concentrated on either the outcomes or the process of learning (Meijer et al., 2006).

Metacognition as a socio-cognitive construct

Metacognition is essential in the strategic self-regulatory application of knowledge and skills to achieve learning goals. Metacognitive self-regulation is thought to be crucial for academic success, especially in higher education (Cordon, 2002). Nevertheless, a majority of higher education students possess insufficient metacognitive knowledge and skills to spontaneously self-regulate their learning (MacLellan & Soden, 2006). However, empirical research leads us to be optimistic that metacognitive knowledge, and especially metacognitive skills, are trainable and teachable (Kuhn, 2000). In this respect, Hartmann and Sternberg (1993) suggest a multi-dimensional approach of (1) promoting metacognitive awareness by learning from modelling; (2) improving metacognitive knowledge and skills by confrontation with and reflection upon a variety of heuristics and self-regulatory skills; and (3) fostering a powerful learning environment challenging learners to judge, control, and manage their learning. With regard to the latter, Hurme et al. (2006), Puntambekar (2006), and Roscoe and Chi (2008) stress the potential of interaction and constructing socially shared knowledge.

The above can be linked to the current research interest about metacognition as a socio-cognitive construct (Iiskala et al., 2011; Volet et al., 2009). According to this view, metacognition has a social dimension and is best promoted through social interactions, in which metacognitive insights and strategies are modelled and consequently internalised. Early research in this field explored the potential of metacognitive modelling by teachers. Recent studies focus on collaborative learning and mediation or modelling by peers (e.g. Hurme et al., 2006; Molenaar, van Boxtel, & Sleegers, 2010; Volet et al., 2009). During collaborative learning, students ask questions, provide explanations, and discuss different viewpoints. Their thinking is compared with their peers', requiring both the knowledge and regulation of their own cognitive processes (Iiskala, 2011; Puntambekar, 2006). They start monitoring and controlling how peers are working (Volet et al., 2009). In other words, during collaborative learning metacognitive activity is mediated among students.

Since it is assumed that higher-level learning, and more specifically metacognitive regulation, can best be accomplished through an exchange of experiences and insights on an equal-ability basis (King, 1997; Volet et al., 2009), literature shows an actual call for empirical research on metacognition and collaborative learning. In this respect, the present study takes an interest in studying the influence of reciprocal peer tutoring on higher education students' metacognitive knowledge and regulation.

Reciprocal peer tutoring

Peer tutoring is a type of collaborative learning, aimed at the acquisition of knowledge and skills through active helping and supporting among peers in small groups or student pairs (Falchikov, 2001; Topping, 2005). Students in a peer tutoring programme take specific roles as tutor and tutee. The tutor is a more knowledgeable student supporting and directing the learning processes through active scaffolding, questioning, and explaining (Roscoe & Chi, 2008). The tutee is a less experienced student receiving help and guidance from the tutor. Reciprocal peer tutoring (RPT), in particular, is characterised by the structured switching of the abovementioned roles at strategic moments during peer learning (Topping, 2005). RPT reaps the specific benefits derived from teaching (tutor) and being taught (tutee). RPT is mostly associated with same-age settings, in which tutors and tutees are from the same class group.

Research lists multiple benefits for both tutees and tutors on cognitive, metacognitive, affective, and social levels (e.g. Falchikov, 2001; Topping, 2005). With regard to the metacognitive effects, Roscoe and Chi (2007, 2008) illustrate that particularly taking the tutor role evokes improvement in comprehension monitoring, demonstrated in tutors' increased elaborative contributions. King (1997) stresses the promotion of metacognitive reflection. Her research reveals significant effects on students' metacognitive monitoring and control, both when tutoring and being tutored. This is confirmed by Ismail and Alexander (2005), stating that - especially scripted - peer tutoring programmes prompt learners to generate more higher-level metacognitive questions and responses, contributing to their metacognitive awareness. The available research helps us to conclude that peer tutors can function as metacognitive role models and can take ownership of their own and their peers' learning (Falchikov, 2001). Thus it appears promising to approach RPT as a pathway to optimise students' metacognitive regulation and knowledge.

Aim and research questions

The present study aims at exploring the potential of a RPT-programme for university students on the promotion of their metacognition. Building on the theoretical framework, we put forward the following research questions: What is the evolution in higher education students' (1) metacognitive knowledge and (2) metacognitive regulation skills from pretest to posttest, at the end of a RPT-intervention?

Method

Participants and setting

The present study was conducted in a naturalistic higher education setting at Ghent University, involving 67 first-year Educational Sciences students who previously obtained a Professional Bachelor degree (10 males and 57 females; 15% and 85%, respectively). Students were randomly assigned to twelve RPT groups. The RPT-programme was a formal component of a 5-credit course "Instructional Sciences". Students received credits for their participation in the RPT-programme.

Intervention

During a complete semester, students tutored each other in a face-to-face context, in small and stable groups of four to six tutees per tutor. The intervention consisted of eight successive sessions (each taking 90 minutes), including a training session. The tutoring programme was same-age and reciprocal by nature (Topping, 2005). Within same-age RPT the tutor role is switched between participants, giving equal opportunities to all learners to benefit from the tutor and tutee role (Falchikov, 2001). In the present study, the tutor role was changed at each session. As a manipulation check, RPT sessions of all groups were observed weekly, to monitor whether students adequately enacted their tutor and tutee role. In the case of inadequate behaviours, immediate feedback was given to ensure treatment fidelity.

Assignments

During the RPT sessions, tutors supported tutees' knowledge construction and self-directed learning while working on authentic assignments, related to four content-specific themes of the "Instructional Sciences" course (i.e. class, school, and policy levels within Instructional Sciences; behaviouristic learning theories; cognitivist learning theories; and constructivist learning theories).

The assignments were identical for all peer groups and were presented as open-ended tasks, implying no standard approach, nor single right answers. The assignments were complex and extensive, implying group members could not solve the task individually. The tasks demanded a high level of cognitive processing, more specifically critical thinking, problem solving, negotiation, and decision making (Puntambekar, 2006). In order to direct students' attention to specific learning content related to the course within these open tasks, each assignment started with an outline of learning objectives. These encouraged students to become acquainted with expectations concerning the focus of peer discussions. Assignments were further divided into two major parts: (1) a subtask aimed at familiarising students with the specific instructional sciences' terminology related to the task and enabling them to gain insight into the relations between these theoretical concepts in the assignment and (2) a subtask in which students were asked to apply these theoretical notions to realistic instructional cases. Appendix A exemplifies the authentic assignments.

Overall tutor training

Building on research evidence that tutors who receive support and training yield better outcomes, all students participated in compulsory preliminary training, organised two weeks before the onset of the tutoring programme (Falchikov, 2001; Parr & Townsend, 2002).The focus of the training was on the acquisition of (meta)cognitive and social skills to moderate group discussions and to facilitate shared knowledge construction (Falchikov, 2001; Puntambekar, 2006). Participants were introduced to the multidimensional nature of tutoring in order to master a mix of tutoring skills. They were informed about and practiced functional skills, such as establishing a safe learning environment (Parr & Townsend, 2002; Topping, 2005), managing peer interactions (Roscoe & Chi, 2008; Webb & Mastergeorge, 2003), asking differentiated and thought-provoking questions (King, 1997), giving constructive feedback (Falchikov, 2001; Nath & Ross, 2001), and scaffolding (Chi, Siler, Jeong, Yamauchi, & Hausmann, 2001). Additionally, these trained tutoring responsibilities were summarised and exemplified in a 9-page manual, which was provided to all students.

Session-specific tutor guide

At each session, the students responsible for the tutor role during a specific week received a session-specific tutor guide, to support and inspire their approach. The function of this tutor guide was twofold. First, it offered additional information regarding the theoretical contents of the specific assignment, for it is assumed that peer support and scaffolding are only appropriate when some difference in knowledge and expertise between the tutor and their tutees exists (Topping, 2005). Second, the guide inspired students to tackle the assignments in a stepwise way: exploring the learning objectives, developing an action plan, checking whether requirements are met, and reflecting on the outcomes and the process of peer collaboration. In this way, the guide implicitly stressed the importance of, and elicited, metacognitive activities. This was summarised in a 'tutor card' with a schematic overview of a stepwise problem-solving approach (see appendix B).

Interim support

In order to provide ongoing support during the intervention, an interim supervision session was organised (Falchikov, 2001; Parr & Townsend, 2002). This supervision session – directed by a university staff member – was set up in small groups of about twelve students, and focussed on sharing experiences and reflecting upon one's tutoring performance. The multiple responsibilities of the tutor, as outlined during the tutor training, served as the starting point. All participants received different statements about specific tutor responsibilities, eliciting self-reflection on one's own performance (e.g. "I go beyond asking knowledge-reviewing questions", "I easily notice silent tutees and know how to activate them"). By discussing these reflections with fellow students (from their own and other RPT groups), students shared experiences and informed each other about personal strengths and weaknesses, and about pitfalls concerning managing peer interactions, creating a rich learning environment, and stimulating knowledge construction. Additionally, there was room for spontaneous discussion on student-initiated reflections, as well as for questions concerning organisational aspects, encountered problems, or insecurities concerning the preparation for the RPT-sessions.

Design and instruments

A multi-method pretest-posttest design was used to measure students' metacognition, combining the administration of a questionnaire about metacognitive knowledge and studying think-aloud protocols about students' metacognitive regulation. By combining self-report questionnaires with think-aloud protocol analysis, we try to meet the research call for applying multi-method designs when assessing metacognition (Moos & Azevedo, 2009; Veenman, 2005).

Off-line self–report questionnaire

All students completed the 'Metacognitive Awareness Inventory' (Schraw & Dennisson, 1994) before and after the intervention. The MAI is based on Brown's (1987) theoretical framework about metacognitive knowledge and regulation. In the present study, we adopted the MAI subscale 'knowledge of cognition' to assess students' metacognitive knowledge and the subscale 'regulation of cognition' to assess their perceived metacognitive regulation. Both MAI subscales have been shown to be reliable (Schraw & Dennisson, 1994). The first subscale consists of 17 items, assessing students' awareness of their declarative, procedural, and conditional metacognitive knowledge. In the present study, Cronbach's α was .78 (pretest) and .81 (posttest). The subscale 'regulation of cognition' comprises 35 items, assessing students' awareness of planning, information management, monitoring, debugging, and evaluation strategies. Cronbach's α in the present study was .90 (pretest) and .89 (posttest). The original scoring system of the MAI was replaced with a six-point Likert-type scale, ranging from 1 (I totally don't agree) to 6 (I totally agree).

On-line think-aloud protocol analysis

Both before and after the intervention, all students individually performed a think-aloud task. The entire task solution process of each individual student was videotaped. By analysing the verbal protocols, students' metacognitive strategies could be tracked and identified (Veenman, 2005; Yang, 2003). This research method is expected not to disturb, nor to influence thought and regulation processes significantly (Ericsson & Simon, 1993; Fonteyn, Kuipers, & Grobe, 1993; van Someren, Barnard, & Sandberg, 1994). Nevertheless, it may slightly slow down task performance (Bannert & Mengelkamp, 2008; Veenman, 2005).

Task. The think-aloud task comprised a text with theoretical background information and a related case relevant to the context of Instructional Sciences. At pretest, the central topic of the think-aloud task concerned evaluation and assessment, its purposes and forms. At posttest, students engaged in a task on inequality in education, its explanations and consequences. Apart from this difference in the content of the topic, all aspects of the think-aloud task and measurement were identical at pretest and at posttest. Students were asked to read the text materials and to solve some thought-provoking questions while verbalising their thoughts. In case of silence, participants were prompted by the assessor to continue thinking aloud (van Someren et al., 1994). The task was developed taking into account research-based guidelines. First, we paid attention to the complexity of the task and the terminology used, by providing an academically written text that was challenging yet comprehensible for students (Bannert & Mengelkamp, 2008; Fonteyn et al., 1993). In this way, we tried to avoid both automated processes (which might arise with academically unchallenging task materials) and cognitive overload (which might arise with overly complex tasks and an abundance of new terminology). Second, the representativeness of the task with regard to the (meta)cognitive processes involved, was taken into account (van Someren et al., 1994). We constructed a task that consisted of multiple parts and questions, in order to create opportunities for students to spontaneously orient, plan, monitor, and evaluate. Third, students were instructed to think aloud, to report on the cognitive actions taking place, but not to justify them. This approach ensured the avoidance of interpretative verbalisations, explaining reasons for cognitive actions (Ericsson & Simon, 1993, van Someren et al., 1994). Last, we adopted mild time constraints, by offering each student a maximum of 30 minutes for task completion (Veenman & Beishuizen, 2004).

Coding scheme. A coding scheme was developed to analyse and code students' verbal protocols. Building on the aforementioned multidimensional nature of metacognition, the coding scheme reflects a variety of skills, activities, and strategies. It mirrors the four basic regulation skills as the main coding categories, each being further specified by multiple components. At the lowest operational level, indicators of metacognitive regulation sometimes take the form of cognitive activities. It is – as stated in the literature – legitimate to infer covert metacognitive activity from overt cognitive actions (Meijer et al., 2006). As a result, the coding scheme specifies how elements of the theoretical framework can be identified in verbal student protocols before commencing the task, during task execution, and upon task completion. Appendix C presents a detailed and illustrated overview of the (sub)categories in the coding scheme.

Orientation takes place prior to task execution and aims at preparing the latter. When orienting, learners ideally analyse the task in order to get acquainted with learning objectives or task demands (Butler, 1998). First, this encompasses exploration of the task subject (Veenman, Elshout, & Meijer, 1997). At a minimum level this involves orientation on the general title (Pressley, 2000). Additionally, learners might also consider subtitles or generally screen task or text materials, and consequently explore the task more extensively by taking into account aspects like its constitution or length. Task analysis further consists of reading task instructions (Meijer et al., 2006). Learners who want to ensure their complete comprehension of the task demands normally engage in more profound orientation, by rereading, citing or even paraphrasing task instructions (Artzt & Armour-Thomas, 1992; Veenman et al., 2005). For some learners, task analysis will result in awareness of perceptions or feelings about the task (Meijer et al., 2006; Veenman et al., 1997). These perceptions mostly involve a consideration of both task-difficulty and one's self-efficacy in relation to the perceived difficulty. Metacognitive orientation is ideally also focussed on exploring the particular content of the academic task involved (Veenman et al., 1997). Content orientation comprises formulating hypotheses about the learning contents to be investigated and/or activation of prior knowledge (Butler, 1998; Meijer et al., 2006). Lastly, learners can extend their orientation activities by structuring (for example underlining or schematising) task instructions, indicating they process task requirements (Desoete, 2007; Veenman et al., 2005).

Metacognitive planning normally takes place at the onset of problem solving, but can also appear during the course of problem solving, for example before executing the next subtask. Planning activities can be directed at the problem-solving approach and/or at a timeframe for task execution (Bannert & Mengelkamp, 2008). Profound planning involves selecting an approach after considering various problem-solving alternatives (Artzt & Armour-Thomas, 1992; Veenman et al., 1997). At a more basic level, however, learners will develop a single (reading) plan for reading text materials (for a reading task) or (action plan) for task execution (Desoete, 2007; Pressley, 2000).

Metacognitive monitoring involves the on-line quality control of one's strategy use, comprehension, and progress (Moos & Azevedo, 2009). Monitoring of strategy use encompasses learners' structuring of text or learning materials by means of highlighting information, making notes, and schematising, indicating their intention to make the learning materials manageable (Meijer et al., 2006; Veenman et al., 2005). Further, students engage in selective text navigation when focusing on specific learning contents or scanning text materials (Meijer et al., 2006; Palinscar & Brown, 1984). The latter is aimed at regulating and optimising the efficiency of the problem-solving process. Monitoring of strategy use further includes the purposeful use of reading strategies. In this respect, learners can decide to adapt their reading pace, to reread information (for example after noticing confusion or when becoming aware of essential information), or to read out loud (Palinscar & Brown, 1984). Finally, monitoring of strategy use can result in awareness of deficiencies and therefore in modification of the problem-solving strategies being used (Butler, 1998; Moos & Azevedo, 2009). Comprehension monitoring refers to control activities focusing on the correctness and comprehensiveness of one's understanding. A first indicator in this respect concerns learners' noting lack of full understanding (Crain-Thoreson, Lippman, & McClendon-Magnuson, 1997; Veenman et al., 1997). In contrast, students may demonstrate comprehension by summarising or reaching conclusions about learning content, or by asking critical questions concerning the content (Crain-Thoreson et al., 1997; Meijer et al., 2006). Comprehension is also demonstrated by quoting or paraphrasing learning content, since repeating the main ideas within a text indicates a checking of one's understanding. More profound comprehension monitoring implies elaboration on learning materials (Bannert & Mengelkamp, 2008; Veenman et al., 1997). Possible indicators in this respect are personal interpretations or exploration of relationships between aspects of the learning content. In addition to monitoring comprehension, students' monitoring activities can also be directed at the progress they make (Butler, 1998; Moos & Azevedo, 2009). More specifically, they can control and reflect on the problem-solving strategies used, the proposed solution for a (sub)task, the available time left for task execution, and the quality of their perceived progress (Meijer et al., 2006).

Upon completion of problem solving, learners ideally engage in metacognitive evaluation. The latter can be directed at both learning outcomes and process factors during task execution (Desoete, 2007). In the first case, learners can check the correctness, the completeness, and/or the effectiveness of proposed solutions (Artzt & Armour-Thomas, 1992). More extensive product evaluation consists of a recapitulation of the search for the provided answers (Meijer et al., 2006; Veenman et al., 2005). In the case of process evaluation, judgements and reflections can be directed towards one's personal efficiency, the perceived task difficulty, and/or one's self-efficacy (Meijer et al., 2006).

Coding strategy. The verbal protocols of all students were transcribed verbatim and coded by means of the coding scheme. Two trained coders performed the coding independently. They double-coded 23% of the protocols. Cohen's kappa (κ = .80) indicates high overall interrater reliability. Interrater reliability for the main categories of the coding scheme indicate equally good agreement beyond chance (κ orientation = .93, κ planning = .98, κ monitoring = .89, and κ evaluation= .82). Since metacognitive regulation is multidimensional by nature, it is clear that multiple activities can be reflected within a single protocol fragment. Therefore, we opted for units of meaning as the unit of analysis (van Someren et al., 1994). In the present study, a unit of meaning is defined as a unit representing a thematically consistent verbalisation of a single metacognitive strategy (Chi, 1997). Each unit of meaning received only one code. Appendix D exemplifies the coding strategy.

Data analysis

The questionnaire data regarding students' self-reported metacognitive knowledge and regulation were analysed quantitatively. Pretest and posttest scores on both subscales of the MAI were compared by means of paired-samples t-tests. The verbal protocols, revealing students' actual use of metacognitive regulation skills, were first coded qualitatively. Next, the occurrence of metacognitive skills and strategies at pretest and posttest was analysed and compared quantitatively (Chi, 1997). Paired-samples t-tests were used to test for significant changes in both the frequency of students' use of metacognitive skills and the type of strategies employed to control and regulate their learning (see Table 2). Cohen's *d* is reported to study the effect size of significant differences in the occurrence of metacognitive skills and strategies.

Results

Descriptive analyses

Descriptive analyses of the MAI-based data show that students report a relatively high amount of metacognitive knowledge, both at pretest (M= 4.31, sd= 0.39) and at posttest (M= 4.37, sd= 0.44). Furthermore, relatively high levels of metacognitive strategy use are reported at pretest (M=4.17, sd=0.44) as well as at posttest (M=4.21, sd=0.44). However, this level of self-reported metacognitive regulation has to be linked to the results of the think-aloud protocol analysis. With regard to the latter, 1273 units of meaning were identified in the pretest, and 2303 units were isolated in the posttest transcripts. This increase in metacognitive utterances can be considered as an indication of the pretest to posttest evolution.

Table 1 presents the frequencies of students' metacognitive skill use during think-aloud problem solving for the entire sample. Analyses of the verbal protocols collected at pretest demonstrate a dominant use of monitoring strategies (83.4%). In contrast, a very limited adoption of metacognitive orientation (7.4%), planning (5.4%), and evaluation (3.8%) is shown at pretest. Measurement of students' actual metacognitive regulation at posttest reveals some important shifts. First, students pay considerably more attention to metacognitive orientation (12.5%). Second, students are considerably more involved in metacognitive evaluation (8.9%). In contrast, we observe a decrease in metacognitive monitoring (74.9%) and in metacognitive planning (3.8%). It is nevertheless important to examine the second level coding categories. For instance, within the types of monitoring activities, there is an increase of particular metacognitive regulation strategies: comprehension monitoring and monitoring of progress play a considerably more important role at posttest.

Table 1. *Occurrence of students' actual use of metacognitive skills (frequencies and percentages)*

Metacognitive skills	Pretest		Posttest	
	Frequency	*%*	*Frequency*	*%*
Orientation	**94**	**7.4**	**286**	**12.5**
Task analysis	89	6.9	229	9.5
Exploring text subject & constitution	30	2.3	113	4.9
Detecting task demands	59	4.6	104	4.5
Becoming aware of task perceptions	0	0.0	12	0.5
Content orientation	5	0.5	49	2.4
Generating hypotheses	3	0.2	16	1.0
Activating prior knowledge	2	0.3	33	1.4
Structuring task instructions	0	0.0	8	0.6
Underlining core concepts	0	0.0	8	0.6
Schematising task instructions	0	0.0	0	0.0
Planning	**69**	**5.4**	**88**	**3.8**
Planning in advance	37	2.9	62	2.7
Planning problem solving approach	34	2.7	58	2.5
Making a time-schedule	3	0.2	4	0.2
Interim planning	32	2.5	26	1.1
Planning problem solving approach	31	2.3	26	1.1
Making a time-schedule	1	0.1	0	0.0
Monitoring	**1062**	**83.1**	**1729**	**74.8**
Monitoring of strategy use	722	56.5	858	36.7
Text structuring	171	13.4	254	10.7
Selective text navigation	262	20.5	297	12.8
(Re)reading	232	18.2	258	11.1
Adapting strategy use	57	4.4	49	2.1
Comprehension monitoring	255	20.0	632	27.8
Noting lack of comprehension	50	4.1	38	1.6
Claiming understanding	88	7.0	155	6.7
Demonstrating comprehension by repeating	90	7.2	188	8.6
Demonstrating comprehension by elaborating	27	2.2	251	10.9
Monitoring of progress	85	7.1	239	10.3
Reflecting on strategy use	30	2.3	90	3.9
Reflecting on the proposed solution	51	4.2	101	4.4
Reflecting on the available time and time-schedule	3	0.4	5	0.2
Reflecting on the quality of the progress made	1	0.2	43	1.8
Evaluation	**48**	**3.8**	**200**	**8.9**
Evaluating learning outcomes	41	3.3	163	7.4
Checking the correctness of the solution	7	0.5	57	2.5
Checking the completeness of the solution	26	2.0	49	2.1
Checking the effectiveness of the solution	0	0.0	44	1.9
Recapitulating the solution	1	0.1	17	0.6
Evaluating learning process	7	0.5	33	1.5
Reflecting on personal efficiency	0	0.0	17	0.8
Reflecting on task-difficulty	4	0.3	13	0.6
Reflecting on self-efficacy	3	0.2	3	0.1

Evolution in students' self-reported metacognitive knowledge and regulation

Results of the paired-samples t-test on students' self-reported metacognitive knowledge reveal no significant difference between pretest and posttest scores (t=-1.25, df=58, p=.215). The changes in students' awareness of metacognitive strategy use appear not to be significant either (t=-0.65, df=58, *p*=.515). However, the results point at a discrepancy in our findings when comparing the questionnaire-based analyses with the actual metacognitive regulation as derived from the think-aloud protocols.

Evolution in students' actual use of metacognitive skills

As revealed in Table 2, multiple significant differences in learners' actual metacognitive regulation are observed at posttest. Students not only apply metacognitive skills more frequently, they show a more varied use during problem solving as well.

Metacognitive orientation

Paired-samples t-tests confirm that students orient themselves significantly more towards problem solving at posttest (t=-18.39, df=58, p<.001, d=3.12). This general tendency of increased metacognitive orientation is moreover reflected in second-level strategies. At posttest, students pay significantly more attention to analysing the task (t=-14.76, df=58, p<.001, d=2.55), structuring the task instructions (t=-3.02, df=58, p<.001, d=0.75), and orienting themselves to the specific content of the learning task (t=-7.81, df=58, p<.001, d=1.52). The changes in metacognitive orientation are mainly due to the significant increase of students' engagement in task-analysis. Moreover, a more varied use of task-analysis strategies can be observed. First, students explore the subject and constitution of the task significantly more (t=-10.97, df=58, p<.001, d=2.03). This is evidenced by significantly more attention being paid to both the general title (t=-11.19, df=58, p<.001, d=2.30) and the subtitles (t=-7.52, df=58, p<.001, d=1.40) of the task and text given, implying a more profound orientation. Second, the results demonstrate that students' actions are significantly more aimed at detecting specific task demands (t=-8.06, df=58, p<.001, d=1.31). In this respect students reread (t=-3.30, df=58, p<.001, d=0.56), quote (t=-3.82, df=58, p<.001, d=0.77), and paraphrase (t=-4.10, df=58, p<.001, d=0.86) task instructions more frequently at posttest. It has to be stressed, however, that the overall occurrence of the above-mentioned strategies remains rather limited. Third, participants engage significantly more in reflection on task characteristics by verbalising their task perceptions (t= -3.85, df=58, p<.001, d=1.32). Although an increase in reflections about task difficulty is observed (t= -3.02, df=58, p=.004, d=0.77), the actual frequency of this regulation type remains marginal (M= 0.13, sd= 0.34).

At posttest, students perform significantly more activities related to content orientation (t=-7.81, df=58, p<.001, d=1.52). The related effect size is large. On the one hand, students generate significantly more hypotheses (t=-3.34, df=58, p<.001, d=0.64). On the other hand, there is a significant increase in students' activation of prior knowledge (t=-8.01, df=58, p<.001, d=1.52).

Table 2. *Results of pre- and posttest think-aloud protocol analysis: Occurrence of metacognitive skills*

Metacognitive skills	Frequency				*t (df)*
	Pretest		*Posttest*		
	M[1]	*SD*	*M*	*SD*	
Orientation	**1.59**	**0.85**	**4.85**	**1.19**	**-18.39 (58)*** **
Task analysis	1.49	0.75	3.73	0.98	-14.75 (58)***
Exploring text subject & constitution	0.51	0.68	1.91	0.70	-10.97 (58)***
Detecting task demands	1.00	0.49	1.76	0.65	-8.06 (58)***
Becoming aware of task perceptions	0.00	0.00	0.20	0.40	-3.85 (58)***
Content orientation	0.08	0.28	0.83	0.70	-7.81 (58)***
Generating hypotheses	0.05	0.22	0.27	0.44	-3.34 (58)***
Activating prior knowledge	0.03	0.18	0.56	0.50	-8.01 (58)***
Structuring task instructions	0.00	0.00	0.14	0.34	-3.02 (58)*
Underlining core concepts	0.00	0.00	0.13	0.34	-3.02 (58)*
Schematising task instructions	0.00	0.00	0.00	0.00	
Planning	**1.17**	**0.93**	**1.49**	**0.73**	**-2.14 (58)**
Planning in advance	0.63	0.55	1.05	0.22	-5.01 (58)***
Planning problem solving approach	0.57	0.49	1.00	0.00	-6.53 (58)***
Making a time-schedule	0.05	0.22	0.07	0.25	-0.37 (58)
Interim planning	0.54	0.62	0.44	0.67	0.90 (58)
Planning problem solving approach	0.49	0.59	0.42	0.67	0.60 (58)
Making a time-schedule	0.02	0.13	0.00	0.00	1.00 (58)
Monitoring	**11.30**	**4.62**	**20.81**	**5.48**	**-10.28 (58)*** **
Monitoring of strategy use	5.54	2.37	6.30	3.04	-1.64 (58)
Text structuring	0.13	2.36	6.30	3.03	-2.47 (58)*
Selective text navigation	4.44	2.23	5.03	2.42	-1.45 (58)
Adapting strategy use	0.96	0.85	0.83	0.98	0.81 (58)
Comprehension monitoring	4.49	3.32	10.76	3.98	-9.88 (58)***
Noting lack of comprehension	0.88	1.24	0.64	0.86	1.50 (58)
Claiming understanding	1.51	1.38	2.64	1.14	-4.93 (58)***
Demonstrating comprehension by repeating	1.72	2.14	3.22	1.81	-4.44 (58)***
Demonstrating comprehension by elaborating	0.47	0.91	4.27	2.39	-11.22 (58)***
Monitoring of progress	1.51	1.33	4.05	1.71	-8.78 (58)***
Reflecting on strategy use	0.51	0.73	1.52	0.99	-7.27 (58)***
Reflecting on the proposed solution	0.89	1.02	1.71	1.26	-4.07 (58)***
Reflecting on the time and time-schedule	0.84	0.33	0.85	0.28	0.01 (58)
Reflecting on the quality of the progress made	0.02	0.13	0.73	0.74	-7.13 (58)***
Evaluation	**0.81**	**0.71**	**3.49**	**1.43**	**-12.67 (58)*** **
Evaluating learning outcomes	0.71	0.62	2.93	1.13	-12.16 (58)***
Checking correctness of the solution	0.10	0.30	0.97	0.55	-10.56 (58)***
Checking completeness of the solution	0.42	0.49	0.83	0.62	-4.07 (58)***
Checking effectiveness of the solution	0.00	0.00	0.74	0.51	-11.19 (58)***
Recapitulating the solution	0.00	0.00	0.29	0.49	-4.49 (58)***
Evaluating the learning process	0.12	0.33	0.58	0.65	-5.00 (58)***
Reflecting on personal efficiency	0.00	0.00	2.88	0.45	-4.84 (58)***
Reflecting on task-difficulty	0.07	0.25	0.22	0.41	-2.42 (58)*
Reflecting on self-efficacy	0.05	0.22	0.05	0.22	0.01 (58)

*p< .05 ***p< .001

[1] M refers to how often an individual student on average uses a metacognitive skill or strategy during think-aloud problem solving at pretest and at posttest.

Metacognitive planning

Although participants engage in metacognitive planning, the results outline that their planning behaviour is rather scarce, both at pretest and at posttest. No overall difference is discerned in metacognitive planning (t=-2.14, df=58, p=.063). Nevertheless, a promising significant evolution regarding the planning of the problem-solving approach was found (t=-6.53, df=58, p<.001, d=1.60). No other sub-skills seemed to be affected in a significant way.

Metacognitive monitoring

A considerable part of the problem-solving process is populated by metacognitive monitoring, both at pretest and at posttest. The t-test results reveal significant shifts in students' monitoring of comprehension (t=-9.88, df= 58, p<.001, d=1.72) and progress (t=-8.78, df=58, p<.001, d=1.67). No significant change could be distinguished in monitoring the use of problem-solving strategies (t=-1.64, df=58, p=.106). Nevertheless, students do show a tendency to structure the contents of the text and task significantly more at posttest (t=-2.47, df=58, p=.016, d=0.46), by making significantly more notes (t=-2.44, df=58, p=.017, d=0.49) instead of merely underlining important text parts (see Table 2). However, these effects mirror only marginal increases.

With regard to comprehension monitoring, more important changes are observed. At posttest, participants significantly claim more understanding (t=-4.94, df=58, p<.001, d=0.90). Instead of merely summarising text content, they tend to ask and answer significantly more critical questions concerning the text (t=-10.16, df=58, p<.001, d=2.07). Additionally, there is an increase in demonstrating comprehension by paraphrasing relevant information (t=-12.36, df=58, p<.001, d=2.03). In line with that, a significant decrease in students' quoting parts of the text is revealed at posttest (t=3.64, df=58, p<.001). The most remarkable shift is related to students demonstrating understanding by elaborating on the text. Whereas participants hardly make use of this strategy at pretest, it becomes a dominant monitoring strategy at posttest (t=-11.22, df=58, p<.001, d=2.29). Students make significantly more text interpretations (t=-9.43, df=58, p<.001, d=1.86) and there is more relating to different information-units (t=-7.42, df=58, p<.001, d=1.51). The results further indicate a decrease, albeit non-significant, in noting lack of comprehension (t=1.51, df=58, p=.137).

When regulating their performance, students significantly increase not only the monitoring of their comprehension, but also the monitoring of their progress (t=-8.78, df=58, p<.001, d=1.64). More specifically, students are significantly more involved in checking the adequateness of their problem-solving strategies during task execution (t=-7.27, df=58, p<.001, d=1.18). Table 2 further indicates a significant shift in controlling the correctness and effectiveness of task solutions in the course of problem solving (t=-4.07, df=58, p<.001, d=0.71). In addition, a significant increase in monitoring the quality of progress is revealed (t=-7.13, df=58, p<.001, d=1.62). In contrast, no changes are observed in students' controlling the available time while executing the task (t=0.01, df=58, p=.999).

Metacognitive evaluation

Compared to pretest, students not only evaluate learning outcomes significantly more at posttest (t=-12.12, df=58, p<.001, d=2.46), they also take the learning process itself significantly more into account (t=-5.00, df=58, p<.001, d=0.92).

The product evaluation of learning outcomes appears to become a prominent strategy at posttest. Students show significantly more control of the correctness of their solution (t=-10.56, df=58, p<.001, d=2.00), the completeness of their answers (t=-4.07, df=58, p<.001, d=0.72), and the effectiveness of their provided solution (t=-11.16, df=58, p<.001, d=2.19). Moreover, participants appear to start to recapitulate their problem-solving steps (t=-4.49, df=58, p<.001, d=1.16). Nevertheless, the latter metacognitive evaluation strategy is only applied in a limited manner.

Additionally, important differences in students' evaluation of the learning and problem-solving process can be distinguished. At posttest, students demonstrate a significant increase in reflection on their personal efficiency (t=-4.85, df=58, p<.001, d=1.24). Furthermore, they reflect more on the task difficulty (t=-2.42, df=58, p=.019, d=0.45). This effect is, however, only marginally significant. No significant changes occur in reflecting on self-efficacy (t=0.001, df=58, p=.998). It should be stressed that the average number of metacognitive strategies related to learning process evaluation remains low.

Discussion

The present study aimed to explore the potential influence of RPT on higher education students' metacognitive knowledge and use of metacognitive regulation strategies. Students tutored each other in a face-to-face setting during nine successive weeks while working on authentic assignments in small peer groups. Their metacognition was assessed using a multi-method pretest-posttest design, combining self-reports with think-aloud protocol analysis. The following research questions were put forward: What is the evolution in higher education students' (1) metacognitive knowledge and (2) metacognitive regulation skills from pretest to posttest, at the end of an RPT-intervention?

Metacognitive knowledge

With regard to the first research question, results reveal that students generally report relatively high levels of metacognitive knowledge. This finding fits in with recent research claiming that university students estimate their metacognitive knowledge to be rather high and extensive (e.g. Hara, Bonk & Angeli, 2000; You & Joe, 2001). They appear to be well aware of their declarative and procedural metacognitive knowledge (Brown, 1987; You & Joe, 2001). Since the development of metacognitive knowledge is correlated with age-related improvements in human memory and cognition, established when learners reach adulthood, this finding is not surprising (Perfect & Schwartz, 2002; Schneider, 2008).

The results indicate that students' metacognitive knowledge did not change significantly from pretest to posttest. This can be explained by theorists stating that – after an initial phase where metacognitive knowledge can be promoted from the early age throughout adolescence – it becomes relatively stable in adult learners (Brown, 1987; Perfect & Schwartz, 2002). Although metacognitive knowledge may improve as students' age increases, the acquisition of this knowledge is not part of natural development (Boekaerts, 1997). This insight encourages researchers to explore initiatives promoting metacognitive knowledge development. In this respect, it is argued that the development of metacognitive knowledge can be fostered by frequent and intensive metacognitive experiences, even with adult learners (McCrindle & Christensen, 1995; White, 1999; White & Frederiksen, 2005). More specifically, collaborative learning environments are assumed to be potentially rich with metacognitive experiences, since students make their thinking visible to peers, often resulting in deeper insights in and adaptation of their own metacognition, including their metacognitive knowledge (Hara et al., 2000; Hurme et al., 2006).

Metacognitive regulation

The second research question addressed the potential influence of RPT on students' metacognitive regulation skills. The results show a clear difference in students' actual use of metacognitive regulation skills at posttest, compared to pretest.

Students' awareness of metacognitive regulation

The results of the self-reports indicate that students judge their metacognitive strategy use to be rather high before, during, and upon completion of task-execution, both at pretest and at posttest. However, we should be careful with this finding, for these high estimations may be invoked by the instrument and method used. Off-line assessment and self-report questionnaires do not always provide a reliable or accurate measure of learners' metacognitive regulation (Meijer et al., 2006; Moos & Azevedo, 2009). It can invoke overestimation of one's metacognitive regulation (Veenman, 2005). Some research clearly shows discrepancies between these off-line measures and actual metacognitive behaviour as observed during task performance (Artelt, Baumert, McElvany, & Peschar, 2003; Meeks, Hicks, & Marsh, 2007). In fact, our comparison of the prospective questionnaire and the data resulting from the think-aloud protocols, confirms this tendency to overestimate metacognitive regulation. In particular, students claim to metacognitively regulate their performance throughout all problem-solving phases but concurrent assessment of their regulation reflects very limited use of orientation, planning, and evaluation skills, especially at pretest. Different reasons for this overestimation of self-reported metacognitive regulation are put forward in literature. First, self-reports can easily elicit social desirable answers (Meeks et al., 2007; Veenman, 2005). Adult learners are well aware of the ideal sequence of problem-solving activities (Artelt et al., 2003). Consequently, the risk of getting social desirable answers increases. Second, students' biased perceptions might be caused by memory failure (Ericsson & Simon, 1993; Veenman, 2005). Since the prospective measurement in this study was aimed at assessing students' metacognitive strategy use in general (i.e. without explicit reference to a specific task) students were expected to reconstruct their regular metacognitive behaviours. Previous research illustrated, however, the constraints of human memory when trying to retrieve information, resulting in inaccurate recollection (Meeks et al., 2007; Son & Metcalfe, 2005).

The discrepancy between students' self-reported and their actual metacognitive behaviour has important implications. It hazards students' engagement in productive self-regulated learning (Winne, 2004), for students regulate their learning in relation to their personal perceptions of their learning approach and its outcomes (Winne & Jamieson-Noel, 2002). Consequently, misinterpretations (i.e. overestimation) of metacognitive regulation will result in persistent use of inadequate or mediocre regulation strategies, since the need for more productive forms of self-regulation will not be experienced (Pintrich, 2002; Zabrucky, 2010). Whereas some researchers claim the mismatch between students' perceived and actual metacognitive behaviour implies a negative impact on their academic achievement (e.g. Schraw & Nietfeld, 1998), others have failed to confirm this result (e.g. Lin & Zabrucky, 1998; Winne & Jamieson-Noel, 2002). It is clear, however, that inadequate self-perceptions impair students' ability to learn significantly (Lin & Zabrucky, 1998; Winne, 2004). From this perspective, the observed discrepancy between students' perceived and actual regulation in the present study confirms the need to promote metacognitive awareness among higher education students (MacLellan & Soden, 2006).

Findings further reveal that participation in the RPT-programme could not establish significant differences in students' perception of their metacognitive behaviour. Shapiro and Niederhauser (2004) found similar results when concluding that explicit metacognitive prompts during learning have a positive influence on students' actual application of various cognitive and metacognitive strategies, but could not improve students' awareness of their metacognitive regulation. An explanation might be found both in the relatively short-term nature of the RPT-intervention and in its rather implicit focus on metacognition. Hartmann and Sternberg (1993) and Kuhn (2000) argue that successful enhancement of students' metacognitive awareness requires long and intensive teaching and modelling of metacognitive skills. Moreover, they stress the necessity to make explicit the modelled metacognitive behaviour. It can be assumed that the present RPT-intervention was too short, and did not make the metacognitive strategies sufficiently explicit.

Students' actual use of metacognitive regulation: occurrence of metacognitive activities

With regard to students' actual use of metacognitive skills, results point in the direction of an increased application and more differentiated use of types of metacognitive regulation strategies. At pretest, students almost exclusively pay attention to monitoring their problem solving and their strategy use. They hardly engage in orientation, planning, or evaluation activities. However, at posttest, students increasingly apply orientation and evaluation strategies, although their activities remain dominantly characterised by metacognitive monitoring. It should be noted, however, that dominance of monitoring is inherent to every learning process, since it refers to the continuous quality control of performance (Moos & Azevedo, 2009). Given that orientation and evaluation strategies can only be applied before commencing and upon completion of task execution, metacognitive monitoring will always dominate (Meijer et al., 2006; Perfect & Schwarz, 2002).

The significant increase in metacognitive orientation and evaluation is worth noting. A possible explanation might be related to the RPT-programme, in particular the design of the RPT learning materials. The assignments and the tutor guide explicitly referred to learning objectives. These not only encouraged students to get acquainted with task requirements and expectations concerning the content of the discussions, but also served as an evaluative reflection tool (Falchikov, 2001). Our findings suggest that students might have internalised this systematically trained orientation and evaluation behaviour.

Further, analyses reveal multiple significant changes in students' metacognitive regulation. A significant difference in the metacognitive planning behaviour of participants could not be distinguished, however. This might be due to the structure of the think-aloud task, considering literature stating that the task can partially influence the outcomes of a think-aloud protocol analysis (van Someren et al., 1994). Since students were instructed to provide answers on two thought-provoking questions concerning a given text, the opportunities for planning the process of problem solving were scarce.

In contrast to metacognitive planning, students revealed a significantly increased use of metacognitive orientation, monitoring, and evaluation at posttest. Despite the medium to large effect sizes (Hattie, 2009), the average occurrence of certain metacognitive strategies remained rather low (see Table 2). Nonetheless, the large effect sizes are in line with previous research about the impact of peer tutoring and peer discussions on students' higher-order thinking and learning (e.g. Ellis, Goodyear, Prosser, & O'Hara, 2006; Ireson, 2004; Rosé & Torrey, 2005). Effects above 0.40 are desired because they indicate an added value and have a greater impact on students' achievement (Hattie, 2009). Taking this into account, RPT might be considered a promising instructional approach to promote metacognitive regulation in higher education.

With regard to metacognitive orientation, major changes can be distinguished on task analysis and content orientation. These are important findings, given the shortage of empirical studies underpinning this regulation strategy.

Our findings also reveal a significant increase in students' metacognitive monitoring of both their comprehension and their progress. The increase in comprehension monitoring might be explained by the theoretical perspective of metacognition as a socio-cognitive construct (Volet et al., 2009). When collaborating with peers, students are confronted by differing interpretations, resulting in negotiations about the meaning of learning content (Puntambekar, 2006). These discussions can be further fostered and optimised by the tutor's thought-provoking questions (King, 1997; Roscoe & Chi, 2008). Consequently, students critically (re)consider their own interpretations and presumably become aware of the need to permanently monitor their comprehension. The key features of tutoring are furthermore assumed to have a direct influence on students' awareness of the necessity to control the efficiency and effectiveness of problem solving (Falchikov, 2001). In particular, the provision of continuous feedback and the modelling of evaluative reflections – two responsibilities that were explicitly outlined in the tutor guide – are essential when fostering students' monitoring of progress (Kuhn, 2000). In contrast to our expectations, no significant change in monitoring of strategy use was observed. This is a rather remarkable result, since research states that tutoring can make learners more attentive towards their problem-solving strategies as it encourages students to implement more profound and strategic learning approaches (Falchikov, 2001; Topping, 2005). However, the design and structure of the think-aloud task might be responsible for the present limited metacognitive monitoring of strategy use (van Someren et al., 1994).

Findings further reveal a significant increase in metacognitive evaluation strategies. Students engage significantly more in evaluating their learning outcomes, and make more evaluative comments concerning their personal efficiency. Nevertheless, product evaluation dominates the reflections about the problem-solving process. The social-cognitive approach towards metacognition can help to explain the increased application of metacognitive evaluation at posttest. The key elements of peer collaboration (i.e. scaffolding, asking thought-provoking questions, reflective modelling, providing feedback, etc.) are hypothesised to foster students' self-reflection and evaluation (Chi et al., 2001, Falchikov, 2001).

Students' actual use of metacognitive regulation: types of metacognitive activities

Our results also point at an increase in more profound and higher-quality strategies at posttest. This is especially obvious in relation to the orientation, monitoring, and evaluation strategies. During orientation, students go beyond the exploration of task requirements by reading task instructions, when they quote and even paraphrase instructions to ensure awareness of task demands. Furthermore, students pay considerably more attention to the title and subtitles in the given text, resulting in a higher activation of prior knowledge. In short, students seem better prepared since they engage in more strategic and profound orientation activities.

In relation to metacognitive monitoring, students develop more structure by making notes instead of merely underlining parts of the text. This suggests that students became more sensitive to the deeper processing of information. It should be noted, however, that this was not a common practice for all participants. In contrast, a clear majority of students engage in high-quality comprehension monitoring at posttest. In this respect, they control their understanding by asking themselves critical and elaborative questions about the content of the task and by answering related questions afterwards. Instead of merely quoting parts of the text, students also show a clear tendency to paraphrase information, checking their comprehension. Furthermore, results reveal a significant increase in students' elaborative comments on the text content. A possible explanation can be drawn from the tutoring literature (e.g. Falchikov, 2001; King, 1997; Roscoe & Chi, 2008; Topping, 2005). Tutors are expected to ask critical questions and to provide cognitive scaffolds to tutees, making them discuss meaning, explore connections, and gain deeper insights into complex theoretical frameworks. It might be assumed that observing this modelled behaviour of cognitively challenging peers eventually becomes internalised.

As to the changes in evaluation strategies, students are more involved in evaluative reflections about the efficacy and efficiency of their problem-solving strategies, both during and upon completion of task execution. Moreover, students make clear judgments about the perceived quality of their activities. When evaluating their learning outcomes they go beyond merely controlling the completeness of their answers, by also summarising and recapitulating the problem-solving process. In some students, this results in an outline of critical aspects to consider in future problem-solving tasks. In sum, it appears that, at posttest, students have the tendency to step back and consider both the task and their performance, with the aim of guaranteeing both comprehension and, in turn, effective problem solving.

Since the present study was conducted in an authentic setting, an experimental design could not be realised for ethical reasons. Consequently, caution is needed when interpreting the abovementioned significant changes in students' metacognitive strategy use, for they cannot exclusively be explained by the students' tutoring experience, or the tutoring literature. Alternative explanations for participants' increased and higher-level use of metacognitive activities at posttest can be found in students' (domain-specific) cognitive gains due to the regular curriculum; their experienced need for self-regulation when getting acquainted with the demands of higher education; and in the provided interim support during the RPT-intervention, aimed at self-reflection.

Various researchers state that metacognitive regulation is strongly related to intellectual ability (e.g. Veenman & Beishuizen, 2004) and correlates with students' cognition (e.g. Prins et al., 2006; Sternberg, 1998) and learning performance (e.g. Coutinho, Wiemer-Hastings, Skowronski, & Britt, 2005; van der Stel & Veenman, 2010). Average to high intellectual learners with appropriate (general and domain-specific) knowledge are expected to demonstrate higher metacognitive skill use, often resulting in higher academic achievement. Additionally, Schneider and Pressley (1997) argue that, in the course of cognitive development, the influence of constraints of the information processing system gradually reduces, resulting in more resources becoming available for metacognitive processes. Moreover, higher levels of both knowledge and experience are assumed to increasingly influence the quality of learners' metacognitive activities (Schneider & Pressley, 1997). Taking this into account, it could be expected that our participants' cognitive gains, related to their semester-long learning experiences within different courses of their regular curriculum, might have resulted in an increased use of (higher-quality) metacognitive skills and strategies at posttest. Moreover, the course "Instructional Sciences" in particular might have had a beneficiary impact on participants' awareness and use of metacognition, for it introduced different theories on learning and instruction, their differentiated benefits and pitfalls, specific learning strategies, and characteristics of deep-level learning and problem solving, including metacognition and self-regulation. It seems plausible to assume that students in the present study might have benefitted metacognitively from gaining these insights. An increased awareness of their personal learning and general problem-solving approach might have resulted in the adoption of a desirable, theoretically driven, execution of the think-aloud task.

Another external factor that might have contributed to the reported metacognitive gains at posttest concerns the experienced need of students to manage and self-regulate their learning in higher education. When engaged in academic tasks and learning processes during their first semester at university, students were presumably faced with the requirement for independent self-regulated learning, self-control, and elaborative thinking (Gynnild, Holstad, & Myrhaug, 2008). It can be assumed that students practiced dealing with these new demands, developing the required metacognitive skills during the course of the semester and demonstrating them at posttest.

Lastly, the potential influence of the interim support, inherent to the RPT-intervention, should also be acknowledged. The formal supervision session on the one hand, the spontaneous – informal – peer discussions on experiences with the innovative tutoring programme on the other hand, might have yielded students' awareness of learning and problem-solving strategies (Falchikov, 2001). Students' engagement in self-reflection could in its turn not only have optimised students' tutoring behaviour but also their metacognitive development (Veenman et al., 2006).

Limitations and recommendations for future research

Although the present study suggests a potentially positive influence of RPT on higher education students' actual metacognitive regulation, further research is needed to verify and explore these results. In this respect, it is advisable to adapt the current design and opt for an experimental pretest posttest design, involving a control group. The absence of the latter is an important methodological constraint of the present study (Mason, 2002). Without a control group, one does not have an objective baseline on which the (differential) outcomes for several groups or an experimental group can be compared, making it hard to claim or even explore the potential beneficiary impact or the specific added value of an instructional approach such as RPT. Additional analyses of videotaped tutoring interactions, resulting in process data on RPT, could also (partially) compensate for the present non-experimental design (Barron, 2003; Mason, 2002). Direct observation of tutoring behaviour and peer interactions could shed light on the occurrence of metacognitive regulation within the RPT groups and corresponding evolutions in time during the course of the RPT-intervention. As such, process data might yield explanations for the statistically generated effects, or at least clarify whether or not the significant increase in students' metacognitive strategy use can be related to their participation in the RPT-programme. Furthermore, the present study has been conducted in a particular setting with a medium-size group of students, studying a specific course in one university setting. Future research should try to replicate the current findings by involving other student populations and alternative instructional settings or knowledge domains.

Limitations have already been suggested in the instruments used. The off-line questionnaire in particular might not have been sensitive enough to accurately measure changes in students' metacognitive knowledge or their awareness of metacognitive strategy use. First, due to reasons of internal consistency, only outcomes on students' general metacognitive knowledge and regulation could be reported. It was, however, not possible to provide accurate differentiated information regarding the theoretical subcomponents within these scales. Second, since the MAI is a self-report instrument, outcomes depend on students' recall of task-performance. When recollecting learning episodes, human memory appears to be rather inaccurate, however (Perfect & Schwarz, 2002; Son & Metcalfe, 2005). Consequently, student responses might represent a biased perception of what metacognitive knowledge and skills they deploy (Artelt et al., 2003). The current study reiterates the validity discussion about off-line metacognitive measures.

While the think-aloud methodology is generally recognised as a useful source of data that can provide insight in the covert (meta)cognitive structures and processes underlying problem solving (Veenman, 2005; Yang, 2003), its limitations should also be recognised. A first risk inherent to thinking out loud concerns the problem of reactivity (Branch, 2000; Stratman & Hamp-Lyons, 1994). Subjects required to verbalise their thoughts while problem solving hear their own voices, which can increase their critical attention to the cognitive activities taking place. As a result, verbal protocols might report on a biased representation of (meta)cognitive processes (Branch, 2000). Second, the subject's level of cognitive development can influence the content of verbal protocols: subjects with lower cognitive abilities more easily encounter cognitive load when engaging in academic task execution, needing their full attention to complete the task (Meichenbaum & Biemiller, 1992). Consequently, little or no capacity is left for verbalising their thoughts during task execution (Stratman & Hamp-Lyons, 1994). Third, verbal reports cover conscious activities from the short-term memory (Yang, 2003), implying that automated processes will not get verbalised by participants (Branch, 2000). Despite these limitations, concurrent think-aloud protocols still provide more accurate data on subjects' actual use of (meta)cognitive strategies and skills, compared to off-line measurements (Veenman, 2005). As already suggested by Meijer et al. (2006) and Veenman (2005), our results provide clear indications for the need to apply multi-method designs in future research, preferably combining multiple concurrent instruments in order to get a full and accurate portrayal of students' metacognition (Moos & Azevedo, 2009).

Conclusion

Although metacognition is critical to successfully achieve learning goals, adult learners' metacognitive self-regulation often appears to be insufficient (MacLellan & Soden, 2006). The present study presented a contribution to both the related theory and practice by exploring the potential of a tutoring initiative enhancing higher education students' metacognition. Results show that RPT appears to be a promising instructional approach fostering metacognitive regulation in particular. Comparison of pretest and posttest data more specifically revealed a significantly increased and more varied use of metacognitive orientation, monitoring, and evaluation skills and strategies. Results of the present study raise the question to what degree ongoing interaction processes between peers and particular tutor and/or tutee behaviour are crucial to ensure and optimise the assumed metacognitive benefits of RPT, and therefore offer interesting directions to gain new insights in peers' regulation of their own and each other's cognition. From this perspective, the present study might serve as a starting point for future research in the emerging field of socially shared metacognitive regulation (Iiskala et al., 2011; Volet et al., 2009).

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Appendix A Example of a RPT-assignment

The epistemologic controversy and instructional behaviourism

Learning objectives

- Explaining the epistemologic controversy within instructional science;
- Clarifying the objectivist viewpoint within epistemology;
- Clarifying the constructivist viewpoint within epistemology;
- Situating the behaviouristic vision on learning and instruction within the epistemologic discussion;
- Explaining the basic principles of instructional behaviourism;
- Designing behaviouristic instruction activities and/or learning materials.

Introduction

In instructional science, an epistemologic discussion is going on about the meaning and the nature of knowledge. On the one hand, adherents of objectivism claim the absolute nature of knowledge. On the other hand, adherents of constructivism state that knowledge reflects personal experiences of the learner and stress the importance of individual knowledge construction based on these experiences. Both epistemologic viewpoints result in different visions on learning and instruction.

Part I: Familiarising with the terminology

Which of the following statements is correct? Explain and motivate your group's point of view.

(1) Instructional behaviourism is mainly based on the epistemology of constructivism.
(2) Instructional behaviourism is mainly based on the epistemology of objectivism.

Part II: Applying the terminology

An educational publisher is planning to bring a new biology handbook on the market, inspired by behaviouristic instructional principles. The target group for this handbook consists of first grade secondary school students. The publisher asks the help of your tutoring group to develop one chapter of this new handbook, in which one of the following themes can be presented: (1) the human body; (2) health care; (3) environmental care. The publisher expects your tutoring group to develop some behaviouristic learning materials and learning and instruction activities for this chapter. Consider potential behaviouristic teaching strategies, learning materials for the student, exercise materials, assignments for the students and the teachers. Attached you can find an excerpt from the national biology standards, that can give insight in the specific learning contents within each of the aforementioned themes.

Appendix B Tutor card

Let the tutees brainstorm

Keep the available time in mind

In advance

- Let the group develop an action plan for task execution
- Ask questions which suggest a purposeful approach for task execution
- Let the tutees decide for themselves how to execute the task

In between

- Check the available time and the progress made
- Delegate the task to check the time frequently regularly to a tutee

Check whether all tutees are participating actively

Check whether the proposed solution is in line with the task demands

Check tutees' comprehension by giving feedback and by asking differentiated questions

Examples of questions:

. What does… mean?

. Summarise the characteristics of… .

. Can you give an example of…?

. In what is … different from/comparable to…?

. Why do you say that?

. Does everyone agree?

. Can you explain why…?

. Can someone elaborate on that?

. What are the strengths/weaknesses of…?

. What can you conclude about …?

Check whether the final task solution corresponds with the task demands

Check to what degree the learning objectives are met by all tutees

Check whether tutees still have questions

Reflect on the peer collaboration

Appendix C Categories of the coding scheme for think-aloud protocols

ORIENTATION		
Task analysis	Exploring subject and design of the task	Reading general title *(e.g. "I read the title and notice the task will be about forms of evaluation.")*
		Reading subtitles *(e.g. "I see the text consists of a theoretical framework and a case. At least that is what the subtitles tell me.")*
		Global text screening *(e.g. "I globally overlook the text page. I turn the page. But the text seems to be only on this side of the page.")*
	Detecting task demands	Reading task instructions *(e.g. "I check what I have to do by reading the instructions.")*
		Rereading task instructions *(e.g. "I want to reread the instructions to make sure I understand them.")*
		Quoting task instructions *(e.g. "Okay, so which forms of evaluation can you find in the case?")*
		Paraphrasing task instructions *(e.g. "I read the task instructions. For the first question, I have to search in the text which forms or evaluation I can find and then I also have to give an example from the case for each of these forms.")*
	Becoming aware of one's task perceptions	Reflecting on task-difficulty *(e.g. "I am not familiar with the theme so the task will probably be challenging.")*
		Reflecting on one's self-efficacy *(e.g. "I will have to read very carefully because I am normally not good in finding the required information in a text.")*
		Considering other task perceptions *(e.g. "It could be interesting. The theme sounds interesting.")*
Content orientation	Generating hypotheses *(e.g. The second part of the text will probably show a classroom example, whereas the first part will go into detail about theoretical concepts.")*	
	Activating prior knowledge *(e.g. The theme is not new for me. I have learned about this in previous courses. I am thinking of product and process evaluation now.")*	
Structuring task instructions	Underlining core concepts *(e.g. I underline 'forms of evaluation' because I have to pay special attention to that.")*	
	Schematising task instructions *(e.g. I schematically write down what is expected from me.")*	
PLANNING		
Planning in advance	Planning problem-solving approach	Developing reading plan *(e.g. "I will first read the full text.")*
		Developing action plan *(e.g. "I will first read the text and highlight information. Afterwards I will solve the questions.")*
		Considering various alternatives for problem-solving *(e.g. "I can first read the full text and look at the questions afterwards. Or I can check the questions first and deduce which parts of the text I should read.")*
	Making a time schedule *(e.g. "I plan to spend maximum ten minutes on processing the text. Then I have twenty minutes left to solve the questions.")*	
Interim planning	Planning problem-solving approach	Developing reading plan *(e.g. "I have finished reading the theory. Now I will concentrate on reading the case.")*
		Developing action plan *(e.g. "Before answering the first question I will reread the theoretical framework. Then I will answer both questions.")*
		Considering various alternatives for problem-solving *(e.g. " I solved the first question, I could evaluate my answer immediately by rereading the text. Or I could focus on the second question first and evaluate both answers at the end.")*
	Making a time schedule *(e.g. "I notice that I have 15 minutes left. I will take my time to provide an answer for the second question, but make sure there is some time left for evaluation afterwards.")*	

MONITORING		
Monitoring of strategy use	Text structuring	Highlighting important information *(e.g. “I underline ‘process evaluation’ in blue and its purpose in green. I need that information for the first question.”)*
		Making notes *(e.g. “Peer evaluation is the sixth form I discover in this text. So I write ‘6’ in the margin and add ‘peers’.”)*
		Schematising *(e.g. “I think it is important to keep the overview. It might help for me to make a scheme on the backside of the page. Summative and formative evaluation are the first parts of the scheme.”)*
	Selective text navigation	Focusing on specific text components *(e.g. “The second question asks about the functions of evaluation. This will be in the theory so I will only read that part.”)*
		Scanning text *(e.g. “I screen the text and pay attention to the word ‘function’ because that is what I am looking for.”)*
	(Re)reading	Reading aloud [student rereads (part of) the text]
		Rereading important information *(e.g. “I reread the part on self-evaluation because it is crucial for the first question.”)*
		Rereading after confusion *(e.g. I don’t get what I just read. I read it again.”)*
		Adapting reading pace *[Student’s reading pace is adapted: reading remarkably slower compared to previous sentences]*
	Adapting strategy use *(e.g. “It does not seem to be necessary to finish reading the full text. I stop and concentrate on solving the questions.”)*	
Comprehension monitoring	Noting lack of comprehension *(e.g. “I am afraid I really don’t understand this text part.”*)	
	Claiming understanding	Concluding on text content *(e.g. “Okay, I get the difference between self and peer evaluation.”)*
		Questioning text content *(e.g. “But I wonder if the teacher has no role at all in case of self-evaluation.”)*
	Demonstrating comprehension by repeating	Quoting text contents *(e.g. So I understand summative evaluation occurs at the end of a learning cycle, for example an examination.”)*
		Paraphrasing text contents *(e.g. “The difference between summative and formative evaluation is in the moment of evaluating.”)*
	Demonstrating comprehension by elaborating	Interpreting text contents *(e.g. “I guess peer evaluation helps students to gain more insight in their own comprehension because they are challenged to judge each other’s work and probably become more aware of their own insight.”)*
		Relating text contents *(e.g. “In the case students can test their knowledge before taking a test. That is a form of self-evaluation.”)*
Monitoring of progress	Reflecting on strategy use *(e.g. “It was a wise idea to structure the text because it is very easy to find the information now.”)*	
	Reflecting on the proposed solution *(e.g. “I made a mistake. I am explaining formative information but I should provide information on its purpose.”)*	
	Reflecting on the available time and the time schedule *(e.g. “I still have enough time for the last question.”)*	
	Reflecting on the quality of the progress made *(e.g. “Okay, the work done so far is quite good.”)*	

EVALUATION	
Evaluating learning outcomes	Checking correctness of the solution *(e.g. "I think I made the right interpretations in my first answer.")* Checking completeness of the solution *(e.g. "I gave five examples, that is enough.")* Checking effectiveness of the solution (*e.g. "I just reread my answer. It is quite okay I guess. At least it is an answer to the question.")* Recapitulating answers *(e.g. "For the first question, I read the text and underlined the different forms of evaluation. Then I read the case and searched for examples. That is how I distinguished product, formative, and teacher evaluation.")*
Evaluating learning process	Reflecting on personal efficiency *(e.g. "I lost a lot of time with the first question, which I misinterpreted. I should have read it better.")* Reflecting on task difficulty *(e.g. "It was tougher than I expected.")* Reflecting on self-efficacy *(e.g. "It went quite well. I am surprised because I am normally not good at keeping my full concentration on a text.")*
OFF-TASK	

Appendix D Examples of units of meaning within a verbal protocol excerpt

Units of meaning in the verbal protocol	Codes
I got two pages. I see it's about assessment and evaluation.	Reading general title (orientation)
I first read the instructions to know what I have to do. And it will also make it easier to pay special attention to some text parts. [student reads in silence]	Reading task instructions (orientation)
Okay, I have to search for different forms of evaluation in the case. And for the second question, I have to tell for which purposes assessment is used.	Paraphrasing task instructions (orientation)
Now I'll read the full text.	Developing a reading plan (planning)
[student starts reading the text out loud] "Evaluation takes a central place in contemporary education. With regard to its functions a distinction is traditionally made between summative and formative evaluation. Summative evaluation takes place at the end of a learning cycle, and checks whether or not students reached one or more leaning objectives; for example, whether certain knowledge or skills are developed, whether a student passed an examination and can start the next class, etc. Formative evaluation, on the other hand, takes place earlier in the learning cycle because it is intended to provide interim feedback to students about …" [student does not finish the sentence].	Non-metacognitive
Wait a moment (…) so there is summative and formative… but what is the difference?	Noting lack of comprehension (monitoring)
I reread this part . [student rereads in silence]	Rereading after confusion (monitoring)
Okay, so summative is at the end, while formative takes place during learning.	Paraphrasing text contents (monitoring)
I want … I am going to underline 'formative' and 'summative' [student underlines in the text]. They are important for the questions.	Highlighting important information (monitoring)

3 Promoting university students' metacognitive regulation through peer learning: The potential of reciprocal peer tutoring

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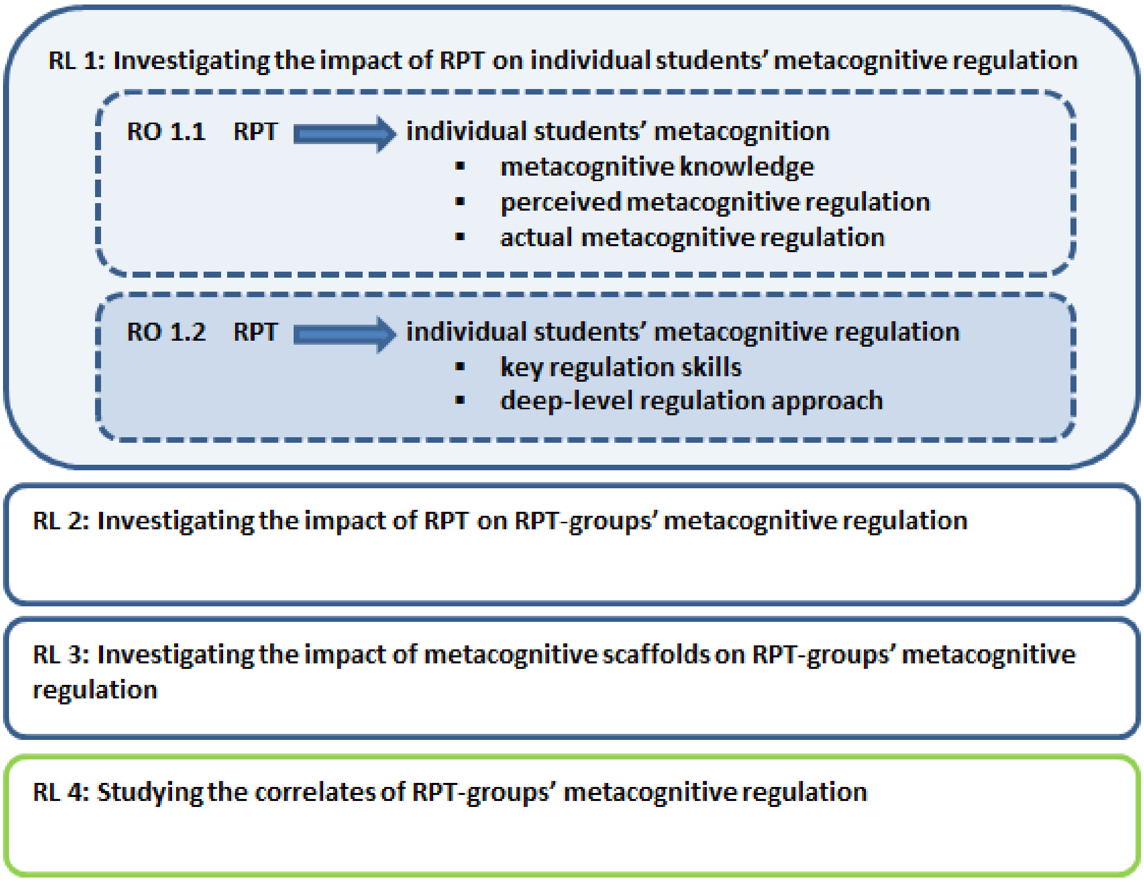

Figure 1. Chapter 3 in relation to the research lines of the dissertation

Chapter 3
Promoting university students' metacognitive regulation through peer learning: The potential of reciprocal peer tutoring

Abstract

Although successful learning outcomes in university education can be advanced by students' competence to self-regulate their learning, university students often possess insufficient metacognitive regulation skills to regulate their learning adequately. The present study investigates changes in university students' adoption of metacognitive regulation after participating in reciprocal peer tutoring (RPT). A quasi experimental pretest-posttest design was adopted, involving an experimental (n=51) and two control groups; CG1 (n=24) and CG2 (n=22). Experimental students participated in a RPT-intervention during a complete semester. Metacognitive regulation was assessed by means of think-aloud protocol analysis. Results indicate that RPT is promising to promote metacognitive regulation in higher education. Experimental students increasingly adopt orientation, monitoring, and evaluation strategies and significantly evolve towards deep-level regulation from pretest to posttest. Except for an increased use of low-level comprehension monitoring, none of the evolutions in experimental students' regulation could be discerned for students in both control groups.

Introduction

Metacognitive regulation is central to self-regulated learning and contributes to an important extent to students' performance (Efklides, 2008; Meijer, Veenman, & van Hout-Wolters, 2006, Zimmerman & Schunk, 2011). It generally advances academic success, especially in higher education since both organisational structures and academic assignments at this educational level emphasise self-management and independent learning (Nota, Soresi, & Zimmerman, 2004). Nonetheless, higher education students' metacognitive regulation is often insufficient to self-regulate their learning adequately (MacLellan & Soden, 2006), revealing the necessity to design, implement, and evaluate initiatives fostering metacognitive regulation.

Although the potential of collaborative learning to foster metacognitive regulation is currently highlighted, empirical research remains scarce (Hadwin, Järvelä, & Miller, 2011; Vauras & Volet, 2013). The present study aims to fill this gap by studying the impact of reciprocal peer tutoring (RPT) on university students' metacognitive regulation. Unlike most other research, this study does not focus exclusively on a particular regulation skill (e.g. monitoring), but takes an integrative perspective when assessing students' metacognitive regulation. It more specifically investigates changes in students' adoption of metacognitive orientation, planning, monitoring, and evaluation after participation in RPT. By enhancing our understanding of the differential impact of RPT on students' adoption of regulation skills, the present study offers direct cues to optimally foster students' metacognitive regulation through RPT.

Theoretical framework

Metacognitive regulation

Metacognition refers to both the awareness and active control that students have over their cognitive activities when engaged in learning or academic problem solving (Brown, 1987; Efklides, 2008, Pintrich, 2004). The first component, metacognitive knowledge, concerns insights of students about themselves as learners, insight into learning strategies, and into the usefulness of these strategies within specific learning conditions (Pintrich, 2002; Schraw, Crippen, & Hartley, 2006; Winne, 2011; Zimmerman & Schunk, 2011). The second component, metacognitive regulation, refers to self-regulatory skills and strategies adopted by students to actively control and coordinate their learning and performance (Greene & Azevedo, 2009; Hadwin et al., 2011; Meijer et al., 2006; Winne, 2011). The focus of the present study is specifically on this second, regulative, component of metacognition. We distinguish orienting, planning, monitoring, and evaluating as key regulation skills (Brown, 1987; Pintrich, 2004; Veenman, Elshout, & Meijer, 1997), which unfold over roughly sequenced and recursive problem solving phases (Greene & Azevedo, 2009; Winne & Hadwin, 1998). When *orienting*, students engage in task analysis to get acquainted with learning objectives or task demands (Butler, 2002, Pintrich, 2004; Winne, 2011). In some learners, this results in awareness of their task perceptions or the activation of prior knowledge (Butler, 2002; Meijer et al., 2006; Winne & Hadwin, 1998). *Planning* generally encompasses selecting and sequencing problem solving strategies, allocating resources, and developing action plans (Greene & Azevedo, 2009; Meijer et al., 2006). This can take place at the onset or during task execution, for example after completing a subtask. *Monitoring* involves the online quality control of students' problem solving, aimed at identifying inconsistencies and at optimising task execution (Meijer et al., 2006; Moos & Azevedo, 2009; Winne, 2011). Comprehension monitoring refers to control activities focusing on the correctness of one's understanding (Efklides, 2008; Pintrich, 2004; Veenman et al., 1997), whereas monitoring of progress focusses on the adequateness of problem solving strategies or the quality of students' progress (Greene & Azevedo, 2009; Moos & Azevedo, 2009). Finally, *evaluation* involves learners' self-judgment upon completion of problem solving (Pintrich, 2004; Veenman, Kok, & Blöte, 2005). This can be directed at both learning outcomes and the learning process (Meijer et al., 2006; Winne & Hadwin, 1998).

Low-level versus deep-level metacognitive regulation

The present study distinguishes low-level and deep-level metacognitive regulation, introducing a more in-depth operationalization. Low-level *orientation* is solely directed at exploring task demands, whereas deep-level orientation aims at processing task demands and activating prior knowledge (Butler, 2002; Veenman et al., 2005). Low-level *planning* implies the development of a single action plan for problem solving, whereas deep-level planning involves selecting an approach after considering various problem-solving alternatives (Meijer et al., 2006; Veenman et al., 1997). When students check their progress or the comprehensiveness of their understanding, they engage in low-level *monitoring*. Reflective comments on the quality of their perceived progress or elaborative, thought-provoking content processing imply deep-level monitoring (Chin & Brown, 2000; Moos & Azevedo, 2009; Roscoe & Chi, 2008). Correspondingly, low-level *evaluation* involves checking and commenting on either learning outcomes or process factors, whereas deep-level evaluation implies reflective judgments on both (Veenman et al., 2005).

Optimising metacognitive regulation through peer tutoring

Fostering metacognitive regulation requires direct observation of explicitly modelled metacognitive behaviour, along with explanations about regulation skills (Schunk & Zimmerman, 2007; Volet et al., 2009). Students should further be challenged to internalise the modelled behaviour at the individual level, by practicing and subsequently reflecting upon a variety of self-regulatory strategies (Hartmann & Sternberg, 1993). Additionally, learners should be encouraged to discuss and control their learning, refining their metacognitive regulation (Efklides, 2008; Hartmann & Sternberg, 1993). Current research centres on modelling by peers during collaborative problem solving (e.g. Iiskala et al., 2011; Volet et al., 2009). During collaborative learning, students discuss meaning and compare their thinking and comprehension with their peers, requiring both regulation of their own cognition and control of how peers learn (Volet et al., 2009). Despite growing consensus on the metacognitive learning opportunities during collaborative learning, empirical evidence on its differential influence on students' adoption of specific regulation skills is limited. The present study aims at enhancing our understanding of the metacognitive potential of collaborative learning, by studying the specific impact of reciprocal peer tutoring on university students' use of orientation, planning, monitoring, and evaluation.

Peer tutoring is characterised by active academic helping and supporting between peers in either small groups or student pairs (Falchikov, 2001; Topping, 1996). One peer, the tutor, is expected to take a direct pedagogical responsibility by creating learning opportunities through questioning, clarifying, and active scaffolding (Chi, Siler, Jeong, Yamauchi, & Hausmann, 2001). The students being cognitively challenged and supported by this peer tutor, are called tutees. Reciprocal peer tutoring (RPT), in particular, is characterised by the structured exchange of the tutor role among peers in the PT-groups/pairs (Topping, 1996). Although the available research illustrates that peer tutoring challenges students' metacognitive regulation and particularly promotes their adoption of monitoring (e.g. King, 1997; Roscoe & Chi, 2008), possible effects on other regulation skills are underexposed.

Aim of the study and research hypotheses

The present study aims at studying the changes in university students' adoption of metacognitive regulation skills after participation in RPT. Since literature provides evidence for metacognitive learning opportunities within collaborative learning (e.g. Hadwin et al., 2011; Iiskala et al., 2011; Volet et al., 2009), we hypothesise that RPT will have a positive impact on students' use of metacognitive regulation skills (hypothesis 1). During tutoring, conceptual discussions can take place at different levels of social interaction: the individual, the dyadic, and the group level (Hadwin et al., 2011). Consequently, students experience the need to metacognitively regulate their own, each other's, or the group's cognition, increasing the chances for metacognitive engagement considerably. Because more regulatory control often results in the use of profound metacognitive strategies (Chin & Brown, 2000; Greene & Azevedo, 2007), we additionally hypothesise that RPT will promote students' involvement in deep-level metacognitive regulation (hypothesis 2).

Method

Design

A quasi-experimental pretest-posttest design was adopted, involving an experimental and two control groups. Experimental students participated in the RPT-intervention during a complete semester. Both at the start (October) and at the end (December) of the semester, the individual metacognitive regulation skills of participants (n=97) were assessed.

Participants and setting

The study was conducted in a naturalistic university setting. The experimental group (EG) consisted of the complete population of 64 first-year students in the Educational Sciences programme who already obtained a Professional Bachelor degree (12.5% males and 87.5% females)[1]. This gender distribution is representative for the Educational Sciences students population in Flanders (Belgium). Unlike other studies (e.g. Cheng & Ku, 2009; Dioso-Henson, 2012; Duran & Monereo, 2005), the present study did not aim to compare RPT with a different type of student-activating learning (e.g. fixed peer tutoring, self-explaining). Therefore, we preferred not to assign

[1] Although all 64 RPT-students participated in the pretest, not all of them attended the posttest assessment. Additionally, the tape recordings of some RPT-students appeared to demonstrate technical problems. Therefore, the collected data of 13 experimental students was excluded from the analysis.

students of the Educational Sciences programme who already obtained a Professional Bachelor degree to either an experimental or control treatment, due to ethical reasons. Such a research design would imply students being deprived from the benefits of peer-assisted learning, inherent to RPT. Alternatively, we involved two control groups. The first control group (CG1) consisted of 24 freshmen in the Educational Sciences programme (12.5% males and 87.5% females). Despite differences in participants' age and prior experience in higher education, these students are enrolled in the same university curriculum as EG-students. This curriculum generally aims at introducing students into the basic theoretical frameworks of Educational Sciences and consists of general social sciences courses, specialised pedagogical courses, and methodology courses. The second control group (CG2) consisted of 22 first-year students in the Social Welfare Studies programme of the same university faculty, who also attained a Professional Bachelor degree (14.3% males and 85.7% females). Although these students are enrolled in a somewhat different curriculum at university, their background and prior experience in higher education is comparable to EG-students. CG2-students' curriculum generally aims at introducing them into the basic theoretical frameworks of Social Welfare Studies and consists of general pedagogical courses, specialised courses in the domain of Social Welfare Studies, and methodology courses. The didactical approach of these courses is comparable to the curriculum of EG- and CG1-students: a dominance of theoretical lectures is alternated with group work, which focusses on writing a theoretical paper with a small group of students. During the research period, students from both control groups attended regular curriculum activities as part of their academic training. They were not involved in tutoring, neither in any comparable collaborative learning approach, encompassing systematic conceptual interaction and discussions among students in a face-to-face setting.

EG-students were randomly assigned to eleven RPT-groups. The RPT-programme was a formal component of the 5-credit course "Instructional Sciences" (of which the theoretical lectures were part of both EG- and CG1-students' curriculum). Informed consent was obtained from all participants in the study.

Intervention

The RPT-intervention consisted of eight successive face-to-face sessions (each taking two hours), in which students tutored each other in small and stable groups of five tutees per tutor. The tutor role was changed at each session. As a manipulation check, all RPT-groups were observed weekly, to control whether students enacted their roles adequately.

RPT-assignments

During each session, students worked on authentic group assignments, related to four content-specific themes of the course "Instructional Sciences". The assignments were presented as open-ended tasks, implying neither a standard approach nor single right answers. Given their complexity and extensiveness, the tasks required group members' collaboration and high levels of cognitive processing (Chi et al., 2001). Each assignment comprised three components: (1) an outline of learning objectives to guide peers' discussions to central course-related topics; (2) a subtask aimed at getting familiar with the theme-specific terminology; and (3) a subtask in which students were instructed to apply theoretical notions to realistic instructional cases.

Training

All EG-students participated in a compulsory tutor training (taking 4.5 hours) one week before the onset of the RPT-intervention. During this training, students were informed about the multidimensional responsibilities of the tutor and were taught a mix of generic tutoring skills. The focus was on establishing a safe learning climate (Barron, 2003), managing and stimulating peer interaction (Chi et al., 2001; Webb, Kersting, & Nemer, 2006), asking differentiated questions (King, 1997; Roscoe & Chi, 2008), giving constructive feedback (Webb et al., 2006), and providing appropriate scaffolds (Chi et al., 2001). An interactive tutor training was set up, making use of videotaped examples of good and bad practices which were discussed in-depth, role plays in which students experienced multiple tutor responsibilities and received feedback on their tutoring approach, and the in-depth analysis of authentic case-studies focusing on specific tutor competences. The outlines of the tutor training were presented in an 9-page manual provided to all EG-students. This manual summarised the contents of the tutor training and allowed students taking the tutor role to activate and reflect upon their knowledge of the required competencies and responsibilities of the peer tutor throughout the RPT-intervention.

Tutor guide

To prepare themselves for the tutor role, tutoring students received a session-specific "tutor guide" one week in advance. This guide consisted of an on average 10-page manual and offered additional information about the theoretical learning content to focus upon in the tutoring session. The latter is important given that the PT-literature stresses the necessity of a difference in tutors' and tutees' domain-specific knowledge (e.g. Falchikov, 2001; Topping, 1996). After each RPT-session, the tutors for the following RPT-session were given their respective tutor guide. Although the theoretical content of the tutor guide differed across sessions, its structure and design were identical throughout the RPT-intervention. In addition to offering theoretical knowledge, the tutor guide inspired students to approach the problem solving process stepwise, by offering them examples of how to explore task demands, develop actions plans, check whether task requirements are met, and reflect on the outcomes of tutoring. From this perspective, the tutor guide implicitly stressed the importance of metacognitive regulation.

Interim support

In order to provide support to the tutors (Falchikov, 2001), both an interim supervision session (taking 2 hours) and two-weekly feedback sessions (each taking 30 minutes) were organised. The supervision session was set up in small groups of twelve students (recruited from two RPT-groups) and directed by a university staff member, who encouraged students to reflect on the adequacy of their behaviour as a tutor and tutee. Additionally, the university staff member provided group-specific feedback once every two weeks. The latter focussed on group dynamics and peer collaboration, equal contribution of all tutees in peer discussions, and on the tutoring approach of the tutors. The feedback often resulted in group reflections and action plans to optimise future peer collaboration.

Instruments

Assessment of students' metacognitive regulation was based on think-aloud protocol analysis. At the start and the end of the research period, all participants individually performed an academic task that was videotaped. Participants were instructed to solve the task and to verbalise their problem solving actions, resulting in verbal protocols (Greene, Robertson, & Croker Costa, 2011; van Someren et al., 1994).

Think-aloud task

The individual think-aloud task comprised of a theoretical text and a real-life case relevant to the course "Instructional Sciences". The pretest version focussed on the course topic 'evaluation', whereas the posttest version focussed on 'social inequity in education'. Students solved thought-provoking questions about the text. In case students stopped verbalising during task performance, they were prompted by the assessor to continue thinking aloud (Veenman, 2005). Apart from a difference in the central topic, all aspects of the think-aloud task and the assessment procedure were identical at pretest and posttest. Both tasks provided a challenging yet comprehensible text, comprised of multiple parts, and had to be executed during the mild time constraint of 30 minutes (Greene et al., 2011; van Someren et al., 1994).

Coding instrument

To analyse students' verbal protocols, we developed a literature-based coding instrument, representing a multi-layered model of metacognitive regulation (see Appendix A). Orientation, planning, monitoring, and evaluation are adopted as the main coding categories and further specified with sub-coding categories (i.e. task analysis, content orientation, planning in advance, interim planning, comprehension monitoring, monitoring of progress, evaluation of learning outcomes, and evaluation of the learning process). Additionally, a dimension on the low-/deep-level approach to metacognitive regulation skills is included. The metacognitive components in the coding instrument, as well as the indicators of the regulative approaches are developed from the literature on metacognitive regulation, as presented in the theoretical part of the present article.

Coding strategy

The verbal protocols of all students were transcribed verbatim and coded by two independent and trained coders. They double coded 25% of the protocols to determine interrater reliability. Cohen's kappa (κ = .78) indicates high overall interrater reliability and good agreement beyond chance for the four main coding categories ($\kappa_{orientation}$= .89, $\kappa_{planning}$= .86, $\kappa_{monitoring}$= .82, and $\kappa_{evaluation}$= .89). The coding procedure followed subsequent phases and focussed exclusively on students' explicitly verbalised behaviour. Each verbal protocol was initially segmented according to the changes in the verbalisation focus, which formed the boundaries of substantial 'episodes' (Chi et al., 2001). An episode is conceptualised as a brief segment of the overall verbal protocol that was centred around one particular action. After segmentation, each episode received a general code, indicating whether it concerned a metacognitive, task-executive, or off-task episode. Second, metacognitive episodes were selected for more detailed 'statement coding' (Roscoe & Chi, 2008). A statement refers to a single thematically-consistent verbalisation of a single metacognitive action. Next, the identified metacognitive statements were coded by means of the developed coding instrument. Every statement first received a general code (indicating the regulation skill it addressed) and afterwards a more differentiated code (referring to the concretised regulation strategies situated in the subcategories of the coding instrument). Additionally, the approach (low/deep-level) to the identified metacognitive statements was coded. Appendix B exemplifies the coding strategy.

Data analysis

First, the frequency of occurrence of all key regulation skills and more concretised regulation strategies, as well as of low-level and deep-level regulation approaches, was calculated for each protocol per participant. The frequency of occurrence of metacognitive regulation skills and approaches in the protocols of individual students was aggregated for each research condition. These frequencies per research condition were used for analysis purposes. Second, pre-analysis investigations were conducted to check both the assumption of normally distributed data (i.e. by means of Kolmogorov-Smirnov tests) and the assumption of homogeneity of variance (i.e. by means of Levene's tests). Since the results revealed that neither assumption was violated, parametric analyses (i.e. ANOVA) were performed to examine the significance of differences in the adoption of metacognitive regulation between research conditions and measurement occasions. Third, a one-way between-subjects ANOVA was conducted to check whether the metacognitive regulation behaviour of students in the three research conditions was comparable at pretest. Fourth, to study the impact of RPT on students' use of metacognitive skills (hypothesis 1) and on their deep-level approach to regulation (hypothesis 2), a two-way mixed ANOVA was performed for each metacognitive skill, using condition (EG/CG1/CG2) as a between-subjects factor and measurement occasion (pretest/posttest) as a within-subjects factor. When significant interaction effects of measurement occasion and condition on students' regulation were indicated, post-hoc comparisons (Bonferroni test) were carried out to compare the main effects. Partial η^2 is reported as a measure of the effect size of significant differences in metacognitive strategy use. The significance level was .05 for all analyses.

Results

Descriptive analysis on students' metacognitive strategy use

Table 1 demonstrates a dominant involvement of all students in metacognitive monitoring, both at pretest and at posttest, whereas their adoption of orientation, planning, and evaluation is rather limited, especially at pretest. Results moreover reveal a clear pretest-to-posttest change towards more frequent use for the majority of metacognitive strategies by EG-students. For some metacognitive behaviour this trend is markedly smaller in both control groups (e.g. comprehension monitoring, evaluation of learning outcomes), while for other metacognitive strategies this positive evolution cannot be discerned at all (e.g. orientation, monitoring of progress). In contrast, the planning behaviour of students appears to evolve similarly for all research groups. Results further reveal students' limited attention to evaluation of the learning process, deep-level monitoring of progress, deep-level planning, and taking into account task perceptions. This is observed at pretest and posttest, in all research conditions. Following Pata et al. (2005), metacognitive regulation strategies with very low frequencies of occurrence (<1%) were removed from further analyses.

Impact of RPT on students' adoption of metacognitive regulation

At pretest, the metacognitive strategy use of EG-students hardly differs from that of CG1- and CG2-students. No significant differences are found between the three conditions in their use of metacognitive orientation ($F(2,94)=1.05$; $p=.364$), planning ($F(2,94)=2.94$; $p=.353$), monitoring ($F(2,94)=1.74$; $p=.182$), or evaluation ($F(2,94)=0.73$; $p=.484$). In contrast, multiple significant differences in learners' metacognitive regulation are observed at posttest.

Results of the mixed ANOVA reveal significant interaction effects between measurement occasion and condition for monitoring ($F(2,94)=94.38$; $p<.001$; *partial* $\eta^2=.66$), evaluation ($F(2,94)=62.19$; $p<.001$; *partial* $\eta^2=.57$), and (albeit to a lesser extent) orientation ($F(2,94)=19.98$; $p<.001$; *partial* $\eta^2=.29$). Pairwise comparisons show that EG-students made significantly more use of these regulation skills at posttest compared to CG1- and CG2-students (see Figure 2a, 2c, and 2d). Both control conditions did not differ significantly from each other. No significant interaction effect between measurement occasion and condition is found for students' planning behaviour ($F(2,94)=0.71$; $p=.496$) (see Figure 2b).

The following paragraph outlines the pretest-to-posttest changes in students' regulation skills in more detail. First, Table 2 reveals major pretest-to-posttest changes in EG-students' comprehension monitoring ($F(2,94)=59.15$; $p<.001$; *partial* $\eta^2=.56$). Compared to CG1-students (*mean difference*=7.73; $p<.001$) and CG2-students (*mean difference*=6.99; $p<.001$), EG-students demonstrate a significantly increased adoption of comprehension monitoring at posttest. Additional analyses on monitoring strategies show a significant interaction effect of measurement occasion and condition on both paraphrasing ($F(2,94)=76.43$; $p<.001$; *partial* $\eta^2=.62$) and elaborative comprehension monitoring ($F(2,94)=48.66$; $p<.001$; *partial* $\eta^2=.50$). Although CG1- and CG2-students also increase significantly in more paraphrasing comprehension monitoring at posttest ($F(1,23)=17.74$; $p<.001$; *partial* $\eta^2=.43$ and $F(1,21)=13.71$; $p<.001$; *partial* $\eta^2=.39$ respectively), the pretest-to-posttest effect is significantly larger for EG-students ($F(1,50)=279,79$; $p<001$; *partial* $\eta^2=.85$). Second, EG-students significantly increase the frequency of monitoring their progress ($F(2,94)=61.21$; $p<.001$; *partial* $\eta^2=.57$) compared to CG1-students (*mean difference*=3.19; $p<.001$) and CG2-students (*mean difference*= 3.51; $p<.001$). Remarkably, our findings indicate a significant negative pretest-to-posttest change for CG2-students for monitoring of progress ($F(1,21)=13.14$; $p<.001$; *partial* $\eta^2=30$). CG1-students' monitoring of progress did not differ significantly from pretest to posttest ($F(1,23)=4.09$; $p=.075$). Third, pairwise comparisons illustrate a significant increase in evaluation of learning outcomes for EG-students ($F(2,94)=65.86$; $p<.001$; *partial* $\eta^2=.58$), compared to CG1-students (*mean difference*=2.00; $p=.004$) and CG2-students (*mean difference*=1.93; $p<.001$). The evaluation behaviour of both control conditions does not differ significantly (*mean difference*=0.07; $p=.928$) and remains limited during the course of the semester.

Although EG-students also significantly increase the frequency of task analysis ($F(2,94)=15.27$; $p<.001$; *partial* $\eta^2=.24$) and the activation of prior knowledge ($F(2,94)=12.41$; $p<.001$; *partial* $\eta^2=.21$), compared to CG1-students (*mean difference*=0.99; $p=.001$ and *mean difference*=0.31; $p<.001$, respectively) and CG2-students (*mean difference*=0.73; $p=.018$ and *mean difference*=0.26; $p=.003$, respectively), these effects on metacognitive orientation are less prominent.

Impact of RPT on students' deep-level approach to metacognitive regulation

Notwithstanding students' tendency to adopt low-level regulation strategies, at pretest and posttest, our findings demonstrate a clear increase in deep-level metacognitive regulation (see Table 2). The major increase can be found for deep-level comprehension monitoring through elaboration on the learning content ($F(2,94)=48.66$; $p<.001$; *partial* $\eta^2=.51$). Pairwise comparisons demonstrate that EG-students experience a significant larger increase in deep-level comprehension monitoring compared to CG1-(*mean difference*=3.61; $p<.001$) and CG2-students (*mean difference*=3.44; $p<.001$). Moreover, EG-students are nearly equally involved in low-level and deep-level comprehension monitoring at posttest, whereas control students predominantly demonstrate a low-level approach (see Table 1). The control conditions do not differ significantly (*mean difference*= 0.18; $p=1.00$).

Table1. *Occurrence of metacognitive regulation at pretest and posttest for the three research conditions (frequencies and percentages)*

Metacognitive regulation	**Prest**						**Posttest**					
	EG (n=51)		***CG1 (n=24)***		***CG2 (n=22)***		***EG (n=51)***		***CG1 (n=24)***		***CG2 (n=22)***	
	Freq.	***%***	***Freq.***	***%***	***Freq.***	***%***	***Freq.***	***%***	***Freq.***	***%***	***Freq.***	***%***
Orientation	**74**	**11.4**	**28**	**9.9**	**37**	**14.6**	**220**	**10.3**	**38**	**8.4**	**35**	**8.3**
task analysis	64	9.9	26	9.2	34	13.4	177	8.3	38	8.4	32	7.6
exploring task demands (LL)	54	8.4	22	7.8	29	11.4	130	6.1	35	7.7	29	6.9
processing task demands (DL)	10	1.5	4	1.4	5	2.0	47	2.2	3	0.7	3	0.7
content orientation	5	0.8	2	0.7	3	1.2	35	1.6	0	0.0	1	0.2
generating hypotheses (DL)	1	0.2	0	0.0	1	0.4	2	0.1	0	0.0	0	0.0
activating prior knowledge (DL)	4	0.6	2	0.7	2	0.8	33	1.5	0	0.0	1	0.2
becoming aware of task perceptions	0	0.0	0	0.0	0	0.0	8	0.4	0	0.0	2	0.5
Planning	**88**	**13.6**	**52**	**18.4**	**42**	**16.6**	**211**	**9.9**	**107**	**23.7**	**100**	**23.7**
planning in advance	28	4.3	14	5.0	17	6.7	76	3.6	29	6.4	27	6.4
formulating problem solving plan (LL)	28	4.3	14	5.0	17	6.7	76	3.6	29	6.4	27	6.4
selecting problem solving plan (DL)	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
interim planning	60	9.3	38	13.4	25	9.9	135	6.3	78	17.3	73	17.3
formulating problem solving plan (LL)	60	9.3	38	13.4	25	9.9	135	6.3	78	17.3	73	17.3
selecting problem solving plan (DL)	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Monitoring	**451**	**69.8**	**193**	**68.5**	**161**	**63.7**	**1473**	**69.0**	**286**	**63.3**	**263**	**62.5**
comprehension monitoring	232	35.9	84	29.8	70	27.7	1016	47.6	190	41.9	202	48.0
noting lack of comprehension	85	13.2	42	14.9	36	14.2	138	6.5	38	8.4	33	7.8
summarizing main ideas	19	2.9	0	0.0	9	3.6	38	1.8	18	4.0	39	9.3
demonstrating comprehension by repeating (LL)	95	14.7	28	9.9	19	7.5	445	20.8	105	23.2	89	21.1
demonstrating comprehension by elaborating (DL)	33	5.1	14	5.0	6	2.4	395	18.5	29	6.4	41	9.8
monitoring of progress	219	33.9	109	38.7	91	36.0	457	21.4	97	21.4	61	14.5
checking of progress (LL)	217	33.6	108	38.3	89	35.2	402	18.8	95	21.0	59	14.0
reflecting on progress (DL)	2	0.3	1	0.4	2	0.8	55	2.6	2	0.4	2	0.5
Evaluation	**33**	**5.2**	**9**	**3.2**	**13**	**5.1**	**231**	**10.8**	**21**	**4.6**	**23**	**5.5**
evaluating learning outcomes	33	5.2	9	3.2	13	5.1	220	10.3	21	4.6	23	5.5
checking learning outcomes (LL)	32	5.0	9	3.2	13	5.1	206	9.6	20	4.4	21	5.0
elaborating on learning outcomes (DL)	1	0.2	0	0.0	0	0.0	14	0.7	1	0.2	2	0.5
evaluating learning process	0	0.0	0	0.0	0	0.0	11	0.5	0	0.0	0	0.0
commenting on learning process (LL)	0	0.0	0	0.0	0	0.0	11	0.5	0	0.0	0	0.0
reflecting on learning process (DL)	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0

Note: LL= low-level; DL= deep-level

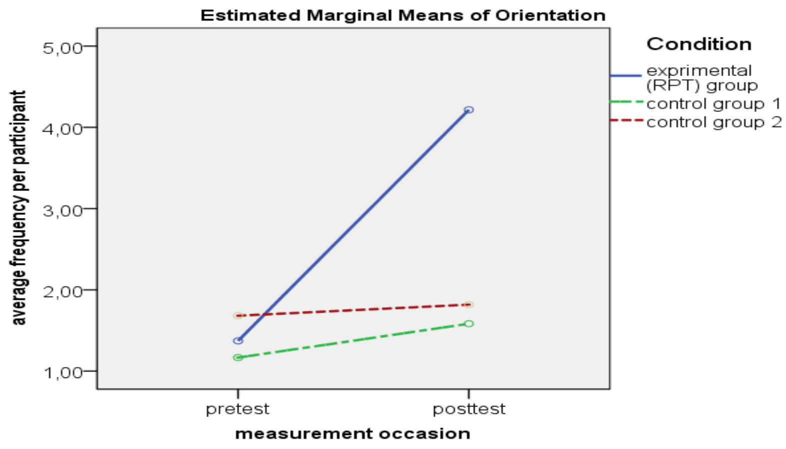

Figure 2a. Pretest-to-posttest change in orientation

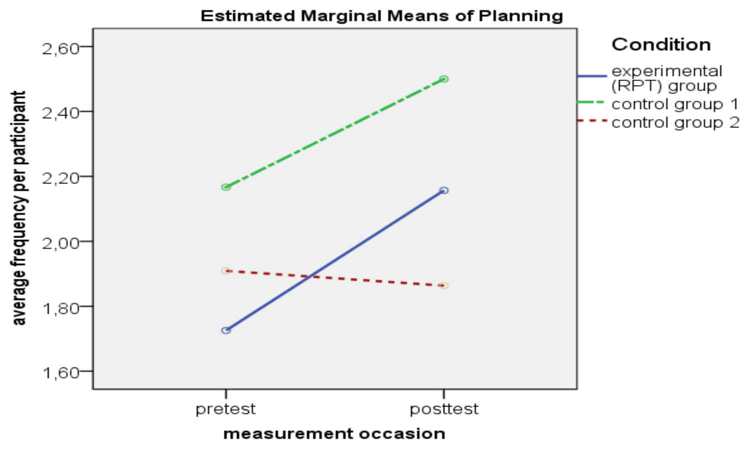

Figure 2b. Pretest-to-posttest change in planning

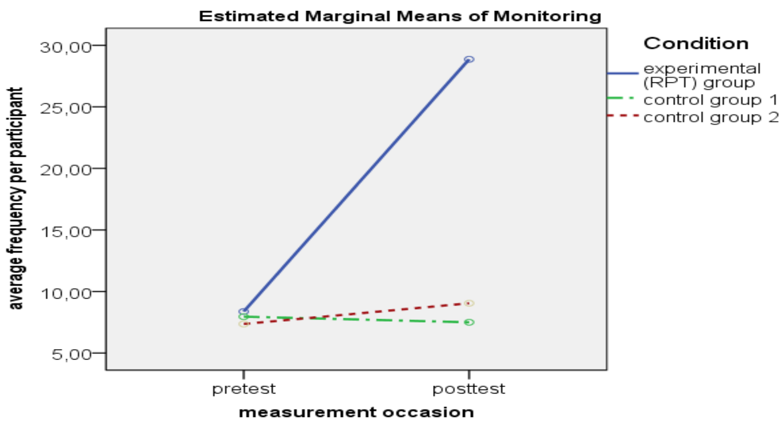

Figure 2c. Pretest-to-posttest change in monitoring

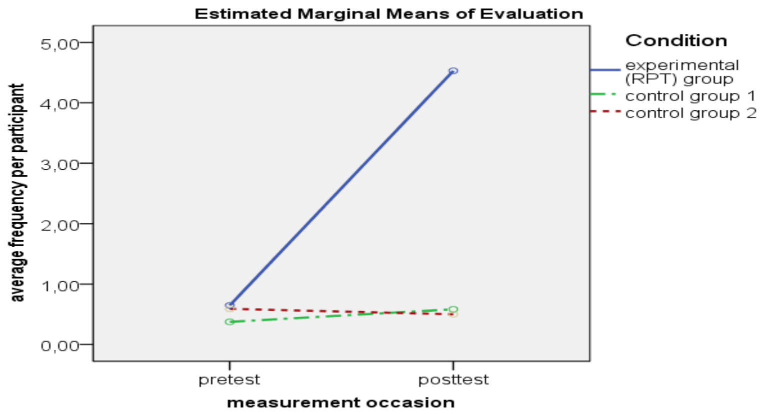

Figure 2d. Pretest-to-posttest change in evaluation

Table 2. *Interaction measurement occasion x research condition on participants' adoption of metacognitive regulation*

Metacognitive skill	**Frequency**				**F (df)**
	Pretest		*Posttest*		
	M	*SD*	*M*	*SD*	
Orientation	**1.39**	**1.22**	**3.02**	**2.16**	**19.98 (2,94)*** **
Task analysis	1.28	1.11	2.55	1.73	15.28 (2.94)***
Exploring task demands	1.08	0.77	2.00	1.11	10.54 (2.94) ***
Processing task demands	0.18	0.55	0.52	0.75	10.64 (2.94) ***
Content orientation	0.10	0.37	0.37	0.54	14.61 (2.94) ***
Activating prior knowledge	0.08	0.34	0.35	0.54	12.41 (2.94) ***
Planning	**1.87**	**1.23**	**2.17**	**1.02**	**0.71(2.94)**
Monitoring	**8.04**	**3.07**	**19.08**	**12.15**	**94.38(2.94)*** **
Comprehension monitoring	3.74	2.23	13.34	8.81	59.15 (2.94) ***
Noting lack of comprehension	1.68	0.96	1.92	1.61	13.20 (2.94)
Summarizing main ideas	0.29	0.61	0.87	0.89	2.67 (2.94)
Demonstrating comprehension by repeating	1.26	1.20	6.02	3.61	49.27 (2.94) ***
Demonstrating comprehension by elaborating	0.54	0.95	4.51	4.61	48.66 (2.94) ***
Monitoring of progress	4.31	1.87	5.76	4.29	61.21 (2.94) ***
Checking progress	4.29	1.89	5.18	3.70	53.11 (2.94) ***
Reflecting on progress	0.05	0.26	0.56	0.81	28.04 (2.94) ***
Evaluation	**0.57**	**0.91**	**2.64**	**2.54**	**62.20 (2.94) *** **
Evaluating learning outcomes	0.57	0.91	2.51	2.39	65.86 (2.94) ***
Checking learning outcomes	0.56	0.86	2.38	2.19	62.55 (2.94) ***
Elaborating on learning outcomes	0.03	0.22	0.14	0.40	7.53 (2,94)*

*p<.05 ***p<.001

An additional but less pronounced increase was found for deep-level monitoring of progress ($F(2,94)=23.04$; $p<.001$; *partial* $\eta^2=.37$). Although EG-students give significantly more reflective comments on the quality of their progress at posttest compared to CG1-students (*mean difference*=0.53; $p=.017$) and CG2-students (*mean difference*=0.46; $p=.004$), their involvement in deep-level monitoring of progress remains low (2.6%). Similar results are found for students' approach to metacognitive orientation and evaluation. Despite significant interaction effects between measurement occasion and condition on deep-level task analysis ($F(2,94)=10.64$; $p>.001$, *partial* $\eta^2=.18$) and deep-level evaluation of learning outcomes ($F(2,94)=7.53$; $p=.002$; *partial* $\eta^2=.13$), students' adoption of these regulation strategies remains limited (i.e. 3.5% and 0.7%, respectively).

Discussion

Impact of RPT on students' adoption of metacognitive regulation

The results of the present study indicated that students are predominantly involved in monitoring their problem solving when executing an academic task, both at pretest and at posttest, in all research conditions. The findings further revealed an increased adoption of monitoring and to a lesser extent evaluation and orientation by EG-students at posttest. Except for low-level comprehension monitoring, the abovementioned positive pretest-to-posttest increases were not discerned in students in the control conditions. The results of the present study consequently demonstrated that RPT is more beneficiary for fostering students' adoption of monitoring and (albeit to a lesser extent) evaluation and orientation, compared to traditional teaching approaches. A significant impact on students' planning behaviour could, however, not be distinguished, not for EG-students neither for students in the control conditions. This might be due to the design of the think-aloud task, for the latter partially determines the outcomes of protocol analysis (Greene et al., 2011; van Someren et al., 1994). Since students were expected to solve three thought-provoking questions on a well-structured academic task, the opportunities to plan task execution were probably scarce. Additionally, students might not have felt the need to sequence problem solving steps within the available time framework. It should further be noted that the developed coding instrument in the present study might not have been sensitive enough to capture students' planning strategies appropriately. Future research should aim to conceptualise metacognitive planning in a more specific way in order to optimise the assessment of students' articulated planning strategies.

Based on our results, RPT appeared to have a critical impact on students' application of comprehension monitoring. During RPT, students were challenged to approach the learning content critically and to negotiate its meaning, resulting in self-questioning (Roscoe & Chi, 2008). It seems plausible to assume that semester-long experience in this cognitively challenging RPT-environment prompted students to internalise this comprehension monitoring behaviour. It should be noted, however, that control students also checked their understanding more often at posttest. Consequently, students' increased involvement in comprehension monitoring might be partially attributed to their experienced need for self-regulation in higher education (Nota et al., 2004). During their first semester at university, all students were presumably faced with the demands for elaborative thinking and self-control of one's understanding, resulting in the adoption of monitoring strategies. Nevertheless, our findings demonstrated that EG-students showed a significant larger adoption of monitoring strategies as compared to students in control conditions, implying an added value of RPT compared to traditional teaching approaches.

Our findings further revealed a clear increase in EG-students' monitoring of progress at posttest. Similarly, EG-students provided significantly more evaluative comments on their learning outcomes. In contrast, students in both control groups did not increase their metacognitive reflection and evaluation, not during the course of problem solving (i.e. when monitoring their progress), neither upon completing it (i.e. during metacognitive evaluation). These findings suggest that RPT is a promising approach when aiming to advance students' evaluative reflections. It can be assumed that the key elements of PT (i.e. asking and answering thought-provoking questions, providing knowledge-building explanations, scaffolding, giving feedback, etc.) directly fostered students' self-reflections and evaluative insights (Chi et al., 2001; Roscoe & Chi, 2008; Webb et al., 2006). Additionally, the design of the RPT-learning materials might have promoted students' evaluative engagements, for the assignments and weekly tutor guides systematically outlined learning objectives, which might have served as an evaluative tool (Zimmerman & Schunk, 2011).

Given EG-students' increased adoption of certain metacognitive regulation strategies, we recommend higher education instructors to implement RPT when aiming to promote university students' metacognitive regulation. The results of the present study more specifically reveal that training students to tutor each other stimulates them to start monitoring their learning more frequently. Additionally, the present study suggests that well-structured and goal-oriented group assignments have the potential to elicit particular evaluation strategies (albeit less pronounced compared to evoking monitoring acts). Consequently, organising RPT requires educators to carefully design learning materials which can encourage students into regulating their learning.

Impact of RPT on students' deep-level approach to metacognitive regulation

Notwithstanding students' dominant use of low-level regulation, at pretest and posttest, our findings revealed significant effects of RPT on students' involvement in deep-level metacognitive regulation. Given that none of the control groups demonstrated significant pretest-to-posttest changes towards a deep-level regulation approach, for none of the key regulation skills, the abovementioned result implies that RPT is more beneficiary to enhance students' engagement in deep-level metacognitive regulation, compared to traditional teaching approaches. Our findings more specifically demonstrated that EG-students particularly outperformed control students in the adoption of deep-level comprehension monitoring. Since tutors were trained to promote tutees' profound reflective thinking by asking critical questions, providing cognitive scaffolds, and giving knowledge-building explanations, it could be assumed that RPT-participants observed and eventually internalised these strategies, modelled by their tutors. EG-students additionally revealed an increased use of deep-level task analysis, profound monitoring of progress, and deep-level evaluation of the learning outcomes. It should be noted, however, that the frequency of occurrence of these deep-level regulation strategies remained low. Students' rather limited involvement in deep-level regulation might be explained by both the need for explicit metacognitive prompts (Schunk & Zimmerman, 2007) and more extensive opportunities to practice regulation skills (Hartman & Sternberg, 1993). Since orientation and evaluation can only be employed before and upon completion of task execution respectively, their frequency of occurrence might have been too limited for students to evolve towards frequent deep-level orientation and evaluation.

Based on our results, we advise higher education instructors to implement long-lasting RPT-interventions, allowing students the time they need to evolve towards more frequent practice with different deep-level regulation strategies. More frequent use of deep-level regulation could increase the chances of students starting to internalise a deep-level approach when regulating their learning. Additionally, it might be advisable to include explicit scaffolds in the RPT-learning materials, which can directly prompt students' engagement in deep-level regulation strategies during all phases of problem solving. More specifically during orientation, evaluation, and planning; three regulation skills which remained rather low-level in the current RPT-intervention, which was characterised by open-ended RPT-assignments, not directing students' regulation. Prompting students' deep-level regulation approach in future research could enhance their regulative engagement in this respect, allowing students to refine and spontaneously adopt a deep-level approach when applying diverse regulation skills.

Limitations and recommendations for future research

Since the present study was conducted in a naturalistic university setting, it was, due to ethical reasons, preferable not to randomly assign students from the same class group to either the experimental or control condition. Although two control groups were involved, these were not completely comparable due to differences in participants' background or their university curriculum. Consequently, caution is needed when interpreting the significant changes in students' metacognitive regulation. Alternative explanations for EG-students' increased use of regulatory strategies can be found in both students' cognitive gains and the emphasis on self-regulation in the course "Instructional Sciences". Empirical research demonstrated that students' metacognitive regulation is correlated to their cognitive actions and performance (Greene & Azevedo, 2007; Zimmerman & Schunk, 2011). Students with higher levels of general and domain-specific knowledge are expected to demonstrate a larger involvement in regulation, often resulting in better performance. Moreover, high levels of knowledge and academic experience are assumed to positively influence the quality of learners' metacognitive skills (Chin & Brown, 2000). This study was set up in relation to the course "Instructional Sciences", that introduces students to theories about learning and instruction, including self-regulation. The particular course context might have enhanced EG-students' problem solving awareness, resulting in a theory-driven execution of the think-aloud task. It should be noted, however, that metacognitive gains based on students' knowledge of "Instructional Sciences" could equally be expected from CG1-students, since the course was also a formal part of their curriculum. Nevertheless, EG-students' increased regulation at posttest was not reflected in the regulation behaviour of CG1-students.

Furthermore, the assessment of students' metacognitive regulation was exclusively based on their verbalised problem solving. It can be assumed, however, that students do not always explicitly articulate their thinking and regulation (Vauras & Volet, 2013; Veenman, 2005), for example when applying automated processes (Greene et al., 2011). This implies that the identification of metacognitive utterances in the think-aloud protocols might not have been exhaustive. Another limitation of think-aloud protocol analysis concerns the risk of reactivity (Veenman, 2005), since asking students to verbalise can increase their attention to their cognitive processing, and consequently result in more metacognitive regulation than they would spontaneously demonstrate. Data triangulation by means of multiple concurrent assessment techniques might therefore be more preferable in future research, in order to gain full and accurate insight into students' metacognitive regulation (Meijer et al., 2006).

Although the results suggested a positive impact of RPT, we currently only report short-term effects. Long-lasting interventions are needed to guarantee an enduring impact. Furthermore, the time-consuming nature of think-aloud protocol coding only allowed for data analysis on a relatively small sample (Roscoe & Chi, 2008). The study was moreover conducted in a particular setting, with students studying a specific course. Future research preferably involves other student populations, alternative instructional settings, or other tutoring formats to increase the representativeness of the findings.

It should further be noted that although the RPT-intervention successfully elicited students' metacognitive monitoring, its effects on the adoption of orientation and evaluation, as well as of deep-level metacognitive regulation (i.e. monitoring and orientation) were less prominent. This might be related to the design and instructions provided in the think-aloud tasks, or to the format of the RPT-assignments (Greene et al., 2011; Perry & Winne, 2013). Both might have stimulated students to particularly check their comprehension and progress but might have been less appropriate to evoke (and consequently assess) other regulative acts. Future research with alternative task formats (e.g. problem solving scripts which guide students more explicitly towards problem solving steps and corresponding regulative acts or learning materials in which scaffolds are included, directly addressing particular regulation skills or a deep-level regulation approach) is needed to examine whether more changes can be discerned in students' adoption of specific regulation skills and approaches after participation in RPT.

Given the observation that the impact of RPT might be stimulated by specific collaboration patterns within particular tutoring groups (Barron, 2003; Chi et al., 2001, Webb et al., 2006), process-oriented investigations can also be a promising future research direction (Roscoe & Chi, 2008; Webb et al., 2006). Analysis of videotaped RPT-sessions could moreover complement the present findings. Direct observation of tutors' and tutees' learning and regulation could unravel when, how, and to what extent metacognitive regulation skills are adopted by RPT-participants and consequently help to explain the potential metacognitive effectiveness of RPT suggested in the current study.

Conclusion

Since the promotion of metacognitive regulation requires explicit modelling and guided practice, increasing student-staff ratios challenges university instructors to successfully support students' regulation (Topping, 1996). The present study demonstrated, nevertheless, that investing time and effort in organising RPT could be a valuable alternative. A RPT-setting concerns a small-scale learning environment and consequently allows for intensive metacognitive modelling by peers and individualised feedback on internalised regulation skills. The results of the present study moreover demonstrated that RPT has the potential to foster university students' adoption of metacognitive regulation. Participation in RPT more specifically increased students' engagement in monitoring. Despite students' additional enhanced involvement in evaluation and orientation, RPT was considerably less influential towards these regulation skills. The effects regarding students' adoption of deep-level regulation were rather limited as well, given that RPT mainly elicited deep-level comprehension monitoring. Based on our findings, we recommend the implementation of RPT in higher education in order to promote students' metacognitive regulation, more specifically their adoption of (deep-level) monitoring strategies. Additionally, we advise instructors to carefully train students for RPT and to design appropriate learning materials which can elicit regulative acts.

The present study not only has the potential to inspire educators when aiming to foster students' metacognitive regulation, it also offers empirical insights enhancing our understanding of students' adoption of particular regulation skills. In this respect, the results about metacognitive orientation and evaluation are promising, given the shortage of empirical studies underpinning both regulation skills. Our findings furthermore raise questions concerning which elements in the RPT-setting specifically evoke metacognitive regulation and therefore present new process-oriented research directions to explore regulation in collaborative groups in depth.

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Appendix A Exemplified overview of the coding categories

ORIENTATION		
Task analysis	Exploring task demands (LL)	*"I read the title and notice the task will be about forms of evaluation."* *"I globally overlook the text page. (…) And now I check what I have to do by reading the instructions."*
	Processing task demands (DL)	*"I've read the instructions. For the first question, I have to search in the text which forms or evaluation I can find and then I also have to give an example from the case for each of these forms."*
Content orientation	Generating hypotheses (DL)	*"The second part of the text will probably show a classroom example, whereas the first part will go into detail about theoretical concepts."*
	Activating prior knowledge (DL)	*"The theme is not new for me. I have learned about this in previous courses. I am thinking of product and process evaluation now."*
Becoming aware of task perceptions		*"I am not familiar with the theme, so the task might be challenging."*
PLANNING		
Planning in advance	Formulating problem solving plan (LL)	*"I will first read the text and highlight interesting information. Afterwards I will try to solve the questions one by one."*
	Selecting problem solving plan (DL)	*"I can first read the full text and look at the questions afterwards. Or I can check the questions first and deduce which parts of the text I preferably read, so reading more purposefully."*
Interim planning	Formulating problem solving plan (LL)	*"Before answering the first question I will reread the theoretical framework. Then I will answer both questions."*
	Selecting problem solving plan (DL)	*"Now that I solved the first question, I could evaluate my answer immediately by rereading part of the text. Or I could focus on the second question first and evaluate both answers at the end."*
MONITORING		
Comprehension monitoring	Noting lack of comprehension	*"I am afraid I really don't understand this text part."*
	Summarising main ideas	*"Okay, product versus process evaluation and summative versus formative. So upon completion versus in the middle of a learning cycle, right? And then there's self- versus peer evaluation. So evaluating your own work versus the work of a classmate."*
	Demonstrating comprehension by repeating (LL)	*"I understand summative evaluation occurs at the end, for example an examination. Actually, the difference between summative and formative is in the moment of evaluating."*
	Demonstrating comprehension by elaborating (DL)	*"In the case, students can test their knowledge before taking a test. That is a form of self-evaluation, I guess."*

Monitoring of progress	Checking of progress (LL)	*"I still have 20 minutes. That's good. Let me just double-check the meaning of formative evaluation, cause I might have interpreted that one incorrectly."*
	Reflecting on progress (DL)	*"I did well by taking enough time to reread the theory until I understood all concepts, because relating the case to the concepts in the second task part should go fast now. I worked efficiently!"*
EVALUATION		
Evaluating learning outcomes	Checking learning outcomes (LL)	*"I gave five examples, that is enough. At least it is an answer to the question."*
	Elaborating on learning outcomes (DL)	*"For the first question, I read the text and underlined the different forms of evaluation. Then I read the case and searched for examples. That is how I distinguished product, formative, and teacher evaluation."*
Evaluating learning process	Commenting on learning process (LL)	*"I lost too much time with the first question. I didn't read it carefully and misinterpreted."*
	Reflecting on learning process (DL)	*"It went quite well. I am surprised, I am usually not good at grasping the key message of a complex text. Highlighting the key words helped me to get through the text. I should do that more often when executing academic tasks because it really helps to keep the overview."*

Note: LL= low-level; DL=deep-level

For some metacognitive regulation strategies (i.e. becoming aware of task perceptions; noting lack of comprehension; summarising main ideas) no approach is indicated, since the distinction between basic (i.e. low-level approach) versus more profound (i.e. deep-level approach) regulative acts is not applicable for these strategies.

Appendix B Exemplified coding strategy

Verbal protocol excerpt	Episode coding	Statement coding	Approach
It's about assessment and evaluation.	Metacognition	Exploring task demands (Orientation)	Low-level
I first read the instructions to know what I have to do. [student reads]	Metacognition	Exploring task demands (Orientation)	Low-level
Okay, search for different evaluation forms. And the second question, tell for which purposes assessment is used.	Metacognition	Processing task demands (Orientation)	Deep-level
Now I'll read the text.	Metacognition	Formulating problem solving plan (Planning)	Low-level
[student reads] "Regarding the functions of evaluation we distinguish summative and formative evaluation. Summative occurs at the end of learning, aimed at controlling whether objectives are reached. Formative evaluation intends to provide interim feedback…" [student does not finish sentence].	Task-execution		
Wait (…) there is summative and formative… but what is the difference?	Metacognition	Noting lack of comprehension (Monitoring)	Low-level
I reread this part . [student rereads silently]	Task-execution		
So summative at the end, formative during learning.	Metacognition	Demonstrating comprehension by repeating (Monitoring)	Low-level
I continue reading (…).	Task-execution		

4 Examining evolutions in the adoption of metacognitive regulation in reciprocal peer tutoring groups

This chapter is based on:

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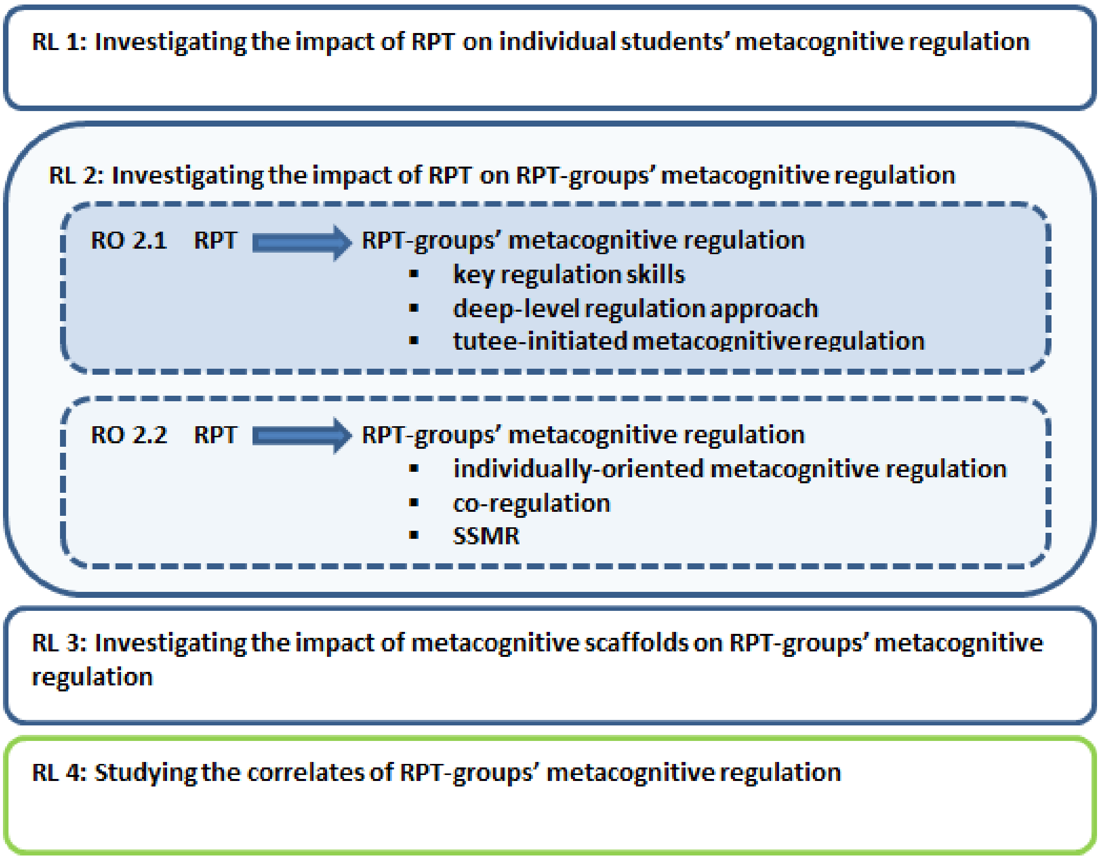

*Figure 1***.** Chapter 4 in relation to the research lines of the dissertation

Chapter 4
Examining evolutions in the adoption of metacognitive regulation in reciprocal peer tutoring groups

Abstract

We aim to investigate how metacognitive regulation is characterised during collaborative learning in a higher education reciprocal peer tutoring (RPT) setting. Sixty-four Educational Sciences students participated in a semester-long RPT-intervention and tutored one another in small groups of six. All sessions of five randomly selected RPT-groups were videotaped (70h of video recordings). Analyses are focussed on identifying time-bound evolutions with regard to (a) the frequency of occurrence of metacognitive regulation, (b) the low-/deep-level approach to regulation, and (c) the initiative (by tutors/tutees) for metacognitive regulation. Logistic regression models allowing change points are adopted to study evolutions over time. The results indicate that RPT-groups increasingly adopt metacognitive regulation (i.e. orientation and evaluation) as the RPT-intervention progresses. Regarding RPT-groups' regulative approach, the results reveal a significant evolution towards deep-level metacognitive regulation (i.e. orientation and monitoring), despite a dominant adoption of low-level regulation strategies. With regard to the initiative, the results demonstrate that tutees start to initiate RPT-groups' monitoring significantly more frequently as they become familiar with the RPT-setting. Orientation, planning, and evaluation remain tutor-centred responsibilities.

Introduction

Recent research stresses the value of collaborative learning when promoting metacognitive regulation (e.g. Hadwin, Järvelä, & Miller, 2011; Schraw, Crippen, & Hartley, 2006; Schunk & Zimmerman, 2007; Vauras & Volet, 2013). During collaborative learning, students explicitly feel the need to regulate the interactions and the learning processes taking place, since they are prompted to engage in collaborative goal setting and conceptual discussions, to control their own and each other's comprehension, and to check collaboratively on learning strategies and outcomes (Hurme, Palonen, & Järvelä, 2006; Volet, Vauras, & Lehtinen, 2009). Despite growing consensus on the facilitative potential of collaborative learning, the role of metacognition in collaborative learning remains unclear, as related empirical research is scarce (Hadwin et al., 2011; Hurme et al., 2006; Iiskala, Vauras, Lehtinen, & Salonen, 2011). We aim at contributing in this respect by analysing the metacognitive regulation behaviour of higher education reciprocal peer tutoring groups. More specifically, evolutions over time concerning the adoption of, the approach to, and the initiative for regulation are studied. In particular, we aim to directly enhance our understanding of metacognitive regulation during collaborative learning by providing an in-depth analysis of how and when regulation is adopted during collaborative learning and identifying critical changes over time regarding students' involvement in specific regulation skills and strategies. Optimising collaborative groups' regulation requires initial insight in learners' regulative behaviour. However, to our knowledge, detailed analyses on evolutions in collaborative learning groups' metacognitive regulation have not been portrayed before. In the present study, we therefore provide an innovative scope in the research on metacognition, extending prior studies which are frequently causal and output-related. Additionally, the present study contributes to the process-oriented studies on peer tutoring (Barron, 2003; Chi, Roy, & Hausmann, 2008; Kumpulainen & Kaartinen, 2003; Roscoe & Chi, 2007) and might serve as a starting point to explore socially shared regulation (Hadwin et al., 2011; Vauras & Volet, 2013). Although we do not examine metacognitive regulation which is shared among tutors and tutees at the interpersonal level, the current findings provide valuable guidelines on how to identify utterances of metacognitive regulation during collaborative learning, which might help to conceptually refine collaborative learners' socially shared focus when adopting particular regulation skills.

Theoretical underpinnings

Metacognitive regulation

Metacognitive regulation refers to a set of self-regulatory skills and strategies used by students to actively control and coordinate their learning (Efklides, 2008; Meijer, Veenman, & van Hout-Wolters, 2006). Based on Brown (1987) and Veenman, Elshout, and Meijer (1997), we distinguish orienting, planning, monitoring, and evaluating as key regulation skills. These regulation skills are further comprised of more concrete regulation strategies, such as task analysis, content orientation, becoming aware of task perceptions, planning in advance, interim planning, comprehension monitoring, monitoring of progress, monitoring of collaboration, evaluating learning outcomes, evaluating the learning process, and evaluating collaboration.

Before commencing academic problem solving, collaborative learners ideally *orient* themselves by analysing the task (Veenman, Kok, & Blöte, 2005; Meijer et al., 2006). Such task-analysis aims at preparing the problem solving process in the group (Veenman et al., 1997) and encourages collaborative learners to set learning goals (De Backer, Van Keer, & Valcke, 2012). Metacognitive orientation can further focus on the task content, resulting in hypothesising on the content or activating prior knowledge (Butler, 2002; Meijer et al., 2006). Both task analysis and content orientation can make students aware of their task perceptions (Veenman et al., 1997).

Metacognitive *planning* encompasses selecting and sequencing problem solving strategies, allocating resources, and formulating action plans (Bannert & Mengelkamp, 2008; Meijer et al., 2006; Veenman et al., 1997). Planning can take place in advance to or during problem solving, for example after completing a subtask.

When students control their own or each other's comprehension or progress, aimed at identifying inconsistencies and modifying problem solving if needed, they engage in metacognitive *monitoring* (Efklides, 2008; Meijer et al., 2006; Moos & Azevedo, 2009). During collaborative learning, students get confronted with alternative interpretations when sharing their understanding, which elicits comprehension monitoring (Hurme et al., 2006; King, 1998; Webb, 2009). The latter refers to the online quality control of the correctness or comprehensiveness of students' understanding (Moos & Azevedo, 2009; Veenman et al., 2005). Monitoring of progress, on the other hand, encompasses checking the adequacy of problem solving or task solutions and appraising the quality of the group's progress in light of learning objectives (Butler, 2002; Moos & Azevedo, 2009; Meijer et al., 2006). Since successful collaborative learning requires mutual contributions from all students, group cohesion, as well as management of peers' interactions (Barron, 2003; King, 1998; Schraw et al., 2006), monitoring activities can also be directed at students' participation and the collaboration in the peer group. In the present study, we conceptualise this as monitoring of collaboration.

Finally, metacognitive *evaluation* involves students' appraisals upon completion of problem solving (Veenman et al., 1997). Students' evaluative comments can be directed at the learning outcomes, the learning process in light of learning objectives, or group members' collaboration (Butler, 2002; Meijer et al., 2006; Veenman et al., 2005).

Approach to metacognitive regulation

Students' metacognitive regulation is characterised by the use of different abovementioned regulatory strategies, associated with students' approach to learning (Case & Gunstone, 2002; Greene & Azevedo, 2007) and the learning activities in the collaborating group (King, 1998; Molenaar, 2011; Rogat & Linnenbrink-Garcia, 2011; Roscoe & Chi, 2007). Deep learning, characterised by integrated knowledge (co-)construction and meaningful understanding, for example, is more often related to regulatory control through reflective thinking (Vermunt, 1996; Roscoe & Chi, 2007) or the use of sophisticated metacognitive strategies (Chin & Brown, 2000; Volet, Summers, & Thurman, 2009). Surface learning, on the other hand, generally provides less opportunities for metacognitive regulation (Case & Gunstone, 2002; Chinn & Brown, 2000; King, 1998; Volet et al., 2009).

In line with the typology of surface and deep approaches to learning, in the present study we distinguish between low-level and deep-level metacognitive regulation, introducing a more in-depth operationalization. Low-level *orientation* is solely directed at exploring task demands, whereas deep-level orientation aims at processing task demands, generating hypotheses about the learning content, and/or activating prior knowledge (Butler, 2002; Veenman et al, 2005). Formulating a single problem solving plan is considered low-level *planning,* whereas deep-level planning implies selecting a plan after considering various problem-solving alternatives (Veenman et al., 1997). Low-level comprehension *monitoring* is often displayed in information-reviewing statements, which merely repeat previously expressed understanding (Chin & Brown, 2000; King, 1998; Roscoe & Chi, 2008). In contrast, reflectively elaborating on previously expressed understanding, represents deep-level comprehension monitoring (Meijer et al., 2006). When students check learning strategies or temporary learning outcomes, they engage in low-level monitoring of progress (Butler, 2002; Moos & Azevedo, 2009). Additionally, they can give reflective comments on the quality of perceived progress, implying deep-level monitoring of progress. Correspondingly, low-level monitoring of collaboration implies commenting on characteristics of the peer group's collaboration, while reflections in this respect are considered deep-level by nature (Barron, 2003; Schraw et al., 2006). Last, low-level *evaluation* involves checking and commenting on learning outcomes, the learning process, or peers' collaboration (Veenman et al., 2005), whereas deep-level evaluation implies reflective judgements.

Eliciting metacognitive regulation through collaborative learning

Metacognitive regulation can be trained and developed, even within adult learners (Kuhn, 2000; Perfect & Schwartz, 2002). Building on the cognitive apprenticeship paradigm, which emphasises learning through guided practice (Collins, Brown, & Newman, 1989), empirical research suggests a multi-dimensional approach to promote students' regulation, with modelling, prompting, and reflection as key components (Hadwin, Wozney, & Pontin, 2005; Schraw et al., 2006). First, students' metacognitive awareness should be raised through direct observation of explicitly modelled metacognitive behaviour at the social level (Schunk & Zimmerman, 2007; Volet et al., 2009). Second, students should be challenged to internalise the modelled behaviour at the individual level, which requires regulative practice in settings where instrumental feedback is available (Hadwin et al., 2005). Such practice encourages students to reflect upon a variety of regulatory strategies, resulting in the optimisation of one's regulation (Schraw et al., 2006; Schunk & Zimmerman, 2007). Third, a powerful learning environment should be established, which prompts students to clarify, control, judge, and regulate their learning (Efklides, 2008; Hurme et al., 2006; Puntambekar, 2006), aimed at consolidating the metacognitive knowledge and skills (Schunk & Zimmerman, 2007).

Collaborative learning might be a promising metacognitive facilitator, for conceptual peer discussions, shared knowledge construction, and joint problem solving prompt students to reflect upon their comprehension and learning process (Goos, Galbraith, & Renshaw, 2002; Hadwin et al., 2011; Iiskala et al., 2011). During collaborative learning peers not only have to discuss about and agree upon "what" they learn, but also on "how" they learn (King, 2002; Topping, 2005). It might therefore encourage students to regulate the peer learning process. Moreover, individual regulative acts might elicit additional metacognitive regulation from collaborating peers (Goos et al., 2002; Webb & Mastergeorge, 2003). Collaborative learning groups might therefore offer students a platform to practice and gradually internalise the regulative knowledge and skills demonstrated on the social level (Chi, Siler, Jeong, Yamauchi, & Hausmann, 2001; Hadwin et al., 2005; Hurme et al., 2006; King, 1998). In the present study, we aim at examining the metacognitive regulation behaviour of collaborative learners, by investigating evolutions in the adopted regulation skills of students participating in reciprocal peer tutoring.

Peer tutoring

Peer tutoring (PT) is characterised by active helping and supporting between peers in either small groups or student pairs (Falchikov, 2001; Topping, 2005). One peer, the tutor, is expected to take a direct pedagogical responsibility (McLuckie & Topping, 2004) by creating learning opportunities in the PT-group through questioning, clarifying, and active scaffolding (Chi et al., 2001; Duran & Monereo, 2005; Roscoe & Chi, 2008). The students being cognitively challenged and supported by this tutoring peer, are called tutees. Reciprocal peer tutoring (RPT), in particular, is characterised by the structured exchange of the tutor role among peers in the PT-groups/pairs (Duran & Monereo, 2005; Topping, 2005) and enables each student to experience the specific benefits derived from providing (tutor) and receiving (tutee) academic guidance (Falchikov, 2001).

RPT is conceptually different from reciprocal teaching (Palincsar & Brown, 1984), in which an expert teacher collaborates with novice learners (i.e. teacher and novices reciprocally take the role of instructor), aimed at fostering students' comprehension monitoring during text reading. Nevertheless, both instructional approaches also share distinctive basic assumptions, such as gradually introducing students to new knowledge and skills by urging them to initiate and direct particular learning or regulation skills; providing calibrated scaffolds and support adapted to novices'/tutees' progressive understanding; and proleptic teaching or guided practice in anticipation of novices'/tutees' growing competence (Palincsar & Brown, 1994; Rosenshine & Meister, 1994). Although peer tutors are not professional teachers and can consequently be considered novices to some extent, they do enter the peer tutoring setting with more knowledge and skills compared to students taking the tutee role (Topping, 1996). Peer tutors' enhanced competence can be established either naturally (e.g. in cross-age peer tutoring, where the tutors are older and have naturally gained more knowledge and experience, compared to their tutees) or by training the peer tutors (Falchikov, 2001). The advanced starting point from which peer tutors enter the PT-setting allows them to lead peer discussions and model (regulation of) learning (King, 1998; Pata, Sarapuu, & Lehtinen, 2005).

In line with Vygotsky's (1978) idea of knowledge being interpersonal before becoming intrapersonal, peer tutors' support should be characterised by a gradual transition from directive tutor-centred (i.e. external) to facilitative tutee-centred (i.e. internal) learning and regulation (Hadwin et al., 2005). Initially, the tutor is expected to initiate and control tutees' learning since tutees enter the PT-setting as novices, both with regard to domain-specific knowledge and the metacognitive regulation of collaborative problem solving (Pata et al., 2005; Rasku-Puttonen, Eteläpelto, Arvaja, & Häkkinen, 2003). At this stage, the peer tutor acts as a model, who dominates the group's cognitive dialogues and demonstrates how learning can be regulated (Hadwin et al., 2005; Schmidt & Moust, 1998). As tutees develop more competence, the peer tutor's support evolves towards coaching behaviour (Schmidt & Moust, 1998). A tutor acting as a coach indirectly prompts tutees' learning and guides their knowledge construction while tutees start to lead the group's cognitive discussions and metacognitive regulation becomes a shared responsibility of tutor and tutees (Pata et al., 2005; Rasku-Puttonen et al., 2003). At this stage, tutees gradually take ownership of regulative actions, which were previously modelled by the tutor, but still rely on the tutor to assist them to take full responsibility for (regulating) the PT-groups' learning (Hadwin et al., 2005). Ultimately, the peer tutor's support fades out when taking the role of consultant (Schmidt & Moust, 1998). At this stage, tutees have sufficiently internalised and automated cognitive and metacognitive strategies to take full ownership of their own and each other's learning and to regulate group processes independently (Hadwin et al., 2005). The tutor's interventions are therefore aimed at fine-tuning or optimising tutees' internally initiated regulation.

Aim of the study and research hypotheses

Although the theoretical underpinnings suggest that (R)PT-settings stimulate students' involvement in metacognitive regulation, process-oriented studies on metacognitive regulation in peer (tutoring) interactions are few (Molenaar, 2011; Roscoe & Chi, 2007; Vauras & Volet, 2013). We aim to investigate how metacognitive regulation is characterised during collaborative learning in RPT-groups, based on measurements of individual RPT-participants' adoption of regulation skills. More specifically, evolutions over time are studied with regard to (a) the frequency of occurrence of metacognitive regulation, (b) the low/deep-level approach to regulation, and (c) the initiative (by tutors/tutees) for metacognitive regulation within RPT-groups. Given its focus on conceptual peer discussions and joint problem solving, we hypothesise that RPT will increasingly elicit RPT-participants' adoption of metacognitive regulation (Goos et al., 2002; Hurme et al., 2006). Since increased regulation often results in the use of more profound metacognitive strategies (Chin & Brown, 2000; Greene & Azevedo, 2007), we furthermore expect that RPT-participants' involvement in deep-level regulation will increase as the RPT-intervention progresses. Given that tutors take a direct pedagogical responsibility (McLuckie & Topping, 2004), they are expected to model regulative behaviour and consequently to dominantly initiate metacognitive regulation in the RPT-groups. Tutees are, however, expected to increasingly demonstrate initiative for regulation as they become more familiar with RPT, for observation of modelled metacognitive behaviour ideally results in internalisation and gradually in regulative practice (Schunk & Zimmerman, 2007).

In sum, the following research hypotheses are put forward. RPT-groups will demonstrate an evolution towards (a) enhanced adoption of all key regulation skills (hypothesis 1); (b) increased adoption of a deep-level regulation approach (hypothesis 2); and (c) enhanced tutee-initiative for (deep-level) metacognitive regulation as the RPT-intervention progresses.

Method

Participants and setting

The study was conducted in a naturalistic university setting. Sixty-four first-year Educational Sciences students who already obtained a Professional Bachelor degree (12.5% males and 87.5%

females) were randomly assigned to eleven RPT-groups. The RPT-programme was a formal component of a 5-credit course “Instructional Sciences”.

RPT-intervention

The RPT-intervention consisted of eight successive face-to-face sessions (including a training session) of two hours each, in which students tutored one another in small and stable groups of six (see Appendix A). The tutor role was interchanged at each session within each RPT-group, implying that all students acted as tutor at least once, whereas some students (i.e. those who were appointed as tutor during the first two weeks of the intervention) tutored their peers twice. The tutor role was randomly assigned to students by a university staff member. During each RPT-session, the tutor was primarily responsible for managing the interactions and stimulating collaborative learning, whereas tutees were occupied with solving the group assignment. As a manipulation check, all RPT-groups were observed weekly, to control whether tutors and tutees enacted their roles adequately.

RPT-assignments

During each session, students worked on authentic group assignments, related to content-specific themes of the course “Instructional Sciences”. The assignments were presented as open-ended tasks, implying neither a standard approach nor single right answers (see Appendix B). Given their complexity and extensiveness, the tasks required students’ collaboration and high levels of cognitive processing. The group assignments more specifically demanded critical thinking, negotiation and decision-making, problem solving, and shared knowledge construction (Chi et al., 2001; Puntambekar, 2006). Each assignment consisted of three components: (1) an outline of learning objectives to guide peers’ discussions to central course-related topics; (2) a subtask aimed at getting familiar with the theme-specific terminology; and (3) a subtask in which students were instructed to apply theoretical notions to realistic instructional cases. Despite differences in the central topic (related to the content-specific theme of the respective RPT-session), all assignments represented the same structure, addressing comparable learning experiences during each RPT-session.

Training

All students participated in a compulsory preliminary tutor training, one week before the onset of the RPT-intervention. During this training, students were informed about the multidimensional responsibilities of the tutor and were taught a mix of generic tutoring skills. The focus was on establishing a safe learning climate (Barron, 2003; Parr & Townsend, 2002), managing and stimulating peer interaction (Chi et al., 2001; Webb & Mastergeorge, 2003), asking differentiated questions (Graesser & Person, 1994; King, 1997), giving constructive feedback (Nath & Ross, 2001; Webb, Ing, Kersting, & Nemer, 2006), and providing appropriate scaffolds (Chi et al., 2001; Molenaar, van Boxtel, & Sleegers, 2010). An interactive tutor training was set up, making use of videotaped examples of good and bad practices which were discussed in-depth, role plays in which students experienced multiple tutor responsibilities and received feedback on their tutoring approach, and the in-depth analysis of authentic case studies focusing on specific tutor competences. Although the tutor training was organised at class-level, its interactive nature frequently required students to share their experiences or ideas about peer tutoring in small groups. The outlines of the tutor training were summarised in a manual provided to all students.

Tutor guide

To prepare themselves for the tutor role, tutoring students received a session-specific "tutor-guide" one week in advance. This guide consisted of an on average 10-page manual and offered additional information about the theoretical learning content to focus upon in the tutoring session. The latter is important given that the PT-literature stresses the necessity of a difference in tutors' and tutees' domain-specific knowledge (e.g. Falchikov, 2001; Topping, 2005). After each RPT-session, the tutors for the following RPT-session were given their respective tutor guide. Although the theoretical content of the tutor guide differed across sessions, its structure and design were identical throughout the RPT-intervention. In addition to offering theoretical knowledge, the tutor guide inspired students to approach the problem solving process stepwise, by offering them examples of how to explore task demands, develop actions plans, check whether task requirements are met, and reflect on the outcomes of tutoring. These problem solving steps were summarised in a schematic overview, provided to each tutor (De Backer et al., 2012). The schematic overview merely reminded tutors to keep in mind important problem solving steps, but was not conceptualised as a script to be followed closely.

Interim support

In order to provide support to the tutors (Falchikov, 2001; Parr & Townsend, 2002), both interim supervision sessions (taking two hours) and two-weekly feedback sessions (each taking 30 minutes) were organised. Halfway through the RPT-intervention, compulsory supervision sessions were organised for all students (see Appendix A). The supervision sessions were set up in small groups of twelve students (recruited from two randomly selected RPT-groups) and directed by a university staff member, who encouraged students to reflect on the adequacy of their behaviour as tutor and tutee. Statements about the multidimensional nature of tutoring served as a starting point to discuss individual students' experiences (both from the tutee and tutor perspective). Additionally, a university staff member provided group-specific feedback every two weeks. The latter focussed on group dynamics and peer collaboration, equal contribution of all tutees in peer discussions, and on the tutoring approach of the tutors. All feedback sessions were characterised by the same structure, procedures, and time frame for each group and each week. The feedback elicited group reflections about strengths and weaknesses of the RPT-group, often resulting in action plans to optimise future peer collaboration. Since both the tutor and the tutee role were addressed, all students of the respective RPT-group attended the group-specific feedback sessions.

Data collection

All RPT-sessions of five randomly selected RPT-groups (i.e. group 2, 3, 5, 8, and 10) were videotaped (resulting in 70 hours of video recordings). This way, the recorded sessions provide insight in students' interaction at the onset, throughout the intervention, and upon completion of the RPT-programme, and consequently allow studying evolutions over time. The video data were recorded in authentic PT-settings and included real-time information about tutors' and tutees' metacognitive interaction.

Coding instrument

To identify utterances of metacognitive regulation in the RPT-groups, a coding instrument 'RPT_MCR' (i.e. reciprocal peer tutoring groups' metacognitive regulation, see Appendix C) was developed based on literature on metacognitive regulation (e.g. Meijer et al., 2006; Molenaar et al., 2010; Veenman et al., 2005) and tutoring/peer interactions (e.g. King, 1997; Roscoe & Chi, 2008; Webb et al., 2006). The instrument represents a multi-layered model of metacognitive regulation in collaborative settings. The four key regulation skills (orienting, planning, monitoring, and evaluating) are adopted as the main coding categories and further specified with sub-coding categories. Additionally, a dimension about the approach to metacognitive regulation is included, explicitly identifying the low-/deep-level nature of diverse regulation strategies. Both the metacognitive strategies and the regulative approaches are developed from the literature on metacognitive regulation, as presented in the theoretical part of this article.

Coding strategy

All videotaped RPT-sessions were coded using the software Nvivo 9, which enabled us to code the recorded sessions on screen without first transcribing the interactions. The coding procedure followed subsequent phases and was exclusively focussed on students' verbalised interaction.

First, the peer discussions in each RPT-session were divided into broad segments by means of episode coding, according to changes in the topic of discussion (Chi et al., 2001). An episode is conceptualised as a rather large segment (including multiple conversational turns by multiple students) of the overall interaction that was centred around one particular topic of discussion. After segmentation, each episode was labelled as either metacognitive regulation, task execution (e.g. problem solving, knowledge transmission, knowledge construction, content processing), or off-task behaviour. Second, metacognitive episodes were reanalysed for more detailed statement at the turn level (Roscoe & Chi, 2008). A metacognitive statement (representing a single conversational turn) refers to a single thematically consistent verbalisation of a single metacognitive action by a single student. Each statement received a code from the RPT_MCR instrument, indicating (a) the general regulation skill it addressed (cfr. main coding categories); (b) the more concrete regulation strategy it represented (cfr. sub-coding categories); and (c) the low- versus deep-level approach it reflected. Last, metacognitive statements were reanalysed to check whether they were initiated by the tutor or by a tutee. Depending on the initiative taker, metacognitive statements received the code 'tutor-initiative' versus 'tutee-initiative'[1]. All metacognitive statements were coded with mutually exclusive categories (i.e. each statement was given only one code from the main coding categories and one code from the sub-coding categories, was coded as either low-level or deep-level, and either tutor-initiated or tutee-initiated). Appendix D exemplifies the coding procedure at the episode and the turn level.

The coding of the video data was accomplished by two independent and trained coders. They were blind to both the RPT-groups and RPT-sessions. Both coders first independently segmented the RPT-discussions of two randomly selected videotaped RPT-sessions into episodes and statements. Next, they compared and checked the identified segments. Discrepancies were resolved through discussion until full agreement was reached. Afterwards, each coder independently coded the segmented episodes and metacognitive statements and subsequently segmented and coded the remaining videotaped RPT-sessions. The coders double-coded 25% of the recorded sessions (5924 statements from 9 randomly-selected RPT-sessions) to determine interrater reliability. Cohen's kappa indicates high interrater reliability for the overall coding (κ = .91) as well as for the coding of 'metacognitive regulation' (κ = .89), and good agreement beyond chance for the four main coding categories ($\kappa_{orientation}$=.81, $\kappa_{planning}$ =.93, $\kappa_{monitoring}$ =.92, and $\kappa_{evaluation}$=.88). The interrater reliability for the coding of 'approach to metacognitive regulation' (i.e. the level of agreement between coders regarding the low- versus deep-level approach to RPT-groups' adopted regulation skills across all coding categories of metacognitive regulation) ($\kappa_{approach\_metacognition}$=.93) and 'initiative for metacognitive regulation' (i.e. the level of agreement between coders regarding tutor- versus tutee-initiative for RPT-groups' adopted regulation skills across all coding categories of metacognitive regulation) ($\kappa_{initiative\_metacognition}$=.97) was equally high.

[1]Apart from the codes 'tutor-initiative' and 'tutee-initiative', a code 'reaction to tutor/tutee' was distinguished, for those metacognitive statements which were not newly initiated, but concerned a reaction to a previous (metacognitive) comment by a peer. Since analysing sequences of conversational turns (e.g. in order to identify utterances of socially shared regulation) was not in the scope of the present study (which focusses exclusively on initiative for regulation in RPT-groups), metacognitive utterances which were coded as 'reaction to tutor/tutee' were not included in the data analysis. This explains why the aggregated proportion of tutor- and tutee-initiative for regulation in Table 4 does not equal 100%.

Data analysis

After coding the video data, the frequency of occurrence of the different metacognitive regulation skills and strategies was calculated for each group and session. In total, 14968 metacognitive statements were identified. In order to investigate whether RPT-groups demonstrate positive evolutions towards enhanced adoption of key regulation skills (hypothesis 1), increased engagement in deep-level regulation (hypothesis 2), and enhanced tutee-initiated regulation (hypothesis 3) as the RPT-sessions progress, mixed models for logistic regression are used. For each metacognitive regulation behaviour (i.e. key regulation skill, deep-level approach, or tutee-initiated regulation), we study (a) the evolution of occurrence rate over time and (b) possible changes in this evolution over time. The structure of the data is as follows. Sessions (i.e. measurement occasions) are clustered within groups. At every session, we are dealing with (grouped) binomial data because the relative number of segments at which the presence of a particular metacognitive regulation behaviour (event) (i.e. key regulation skill, deep-level approach, or tutee-initiated regulation) is measured. We study the evolution of the proportion of events over segmentation units by modelling the effect of session on this proportion.

In a first step, data from the seven RPT-sessions were re-grouped in three intervention phases, in order to unravel general trends in RPT-groups' metacognitive regulation from the starting (sessions 1-2) over the intermediate (sessions 3-4) to the closing (sessions 5-7) phase. Let Y_{ijk} denote the occurrence of an event of interest in segmentation unit k at phase j ($j=1,2,3$) in group i ($i=2,3,5,8,10$), for example the presence ($Y_{ijk}=1$) or absence ($Y_{ijk}=0$) of a particular metacognitive regulation behaviour (i.e. the adoption of a key regulation skill, a deep-level regulation approach, or tutee-initiated regulation). Using mixed models for logistic regression, the odds of $Y_{ijk}=1$ is modelled as a function of phase[2]. More specifically, we fit the following model:

$$\operatorname{logit}\left(P\left(Y_{ijk}=1\right)\right)=\log\left(\frac{P\left(Y_{ijk}=1\right)}{1-P\left(Y_{ijk}=1\right)}\right)=\beta_{0i}+\beta_1 I_{1j}+\beta_2 I_{2j}$$

with random intercept β_{0i} (group-specific intercept) to account for the fact that groups are observed at different time points. $I_{1j}=1$ when phase j is equal to the starting phase and 0 otherwise. Likewise, $I_{2j}=1$ if phase j is equal to the closing phase and 0 otherwise. In this model, $\exp(\beta_1)$ represents the odds ratio of $Y_{ijk}=1$ for starting versus intermediate phase while $\exp(\beta_2)$ is equal to the odds ratio of $Y_{ijk}=1$ for closing versus intermediate phase. In these models, the interpretation of the fixed effects, $\exp(\beta_1)$ and $\exp(\beta_2)$, is conditional on the random effect which means that the effect of phase represents the within-group evolution. Since in our case, the variance of the random effect is low for all models considered (results not shown), the effects can be given the interpretation of an averaged effect over all groups (Agresti, 2002).

[2] It should be noted that only metacognitive regulation strategies with a sufficient frequency of occurrence were selected for mixed models logistic regression analysis. Following Molenaar et al. (2010) and Pata et al. (2005), we used the results of the descriptive analysis as a selection criterion: metacognitive strategies with an average occurrence of less than 2% were excluded from further analyses.

In a second step, for the metacognitive regulation behaviour that shows a statistically significant change in occurrence over the phases, we further explored whether this change varies over sessions and if so, at which RPT-session a change in evolution rate occurs. In this respect, we use mixed models for logistic regression with change points (Pastor & Guallar, 1998).

Consider the following model:

$$\text{logit}\left(P\left(Y_{ijk}=1\right)\right)=\log\left(\frac{P\left(Y_{ijk}=1\right)}{1-P\left(Y_{ijk}=1\right)}\right)=\gamma_{0i}+\gamma_1 j+\gamma_2(j-j_1)I_{(j\geq j_1)}$$

with random intercept γ_{0i} (group-specific intercept) to account for the fact that occurrence rates for the same groups are measured at different sessions. *j* now represents the session number (*j=1,2,3,4,5,6,7*). $I_{(j\geq j_1)}=1$ if $j\geq j_1$ and 0 for $j<j_1$. In this model, the effect of session number on the logit scale equals γ_1 for sessions up to session j_1 but changes at session j_1 after which it becomes $\gamma_1+\gamma_2$; j_1 is termed a change point. In this way, the model allows modelling a change in evolution rate after session j_1. For each event, we consider six different models: a model without change points and models with change points at respectively *j=2,3,4,5,* and *6*. To avoid overfitting of the data, we only allow one change point per model. The best fitting model for each event is selected based on its AIC (i.e. Akaike information criterion). If a model with change point $j=j_1$ is selected, shifting from one session to the next session changes the odds of showing particular metacognitive regulation behaviour with factor exp(γ_1) for $j<j_1$ and with a factor exp($\gamma_1+\gamma_2$) for $j>=j_1$. If exp (γ_1)≠1, this indicates that there is an evolution in the likelihood of event occurrence, either positive (exp (γ_1) >1) or negative (exp (γ_1) <1). If exp(γ_2)=1, this evolution is constant over time. If exp(γ_2) ≠1, the evolution is constant until the change point after which it increases (exp(γ_2)>1) or decreases (exp(γ_2)<1). In these models, the interpretation of the fixed effects, exp(γ_1) and exp(γ_2) is conditional on the random effect which means that the effect of session represents the within-group evolution. As before, the variance of the random effect is low for all models considered (results not shown) and hence, the effects can be given the interpretation of an averaged effect over all groups (Agresti, 2002).

During a single session, typically a lot of segmentation units are observed (see Table 1). To not only focus on the statistical significance of the effects, we also consider confidence intervals for the odds ratios. We further calculate the logit d effect size (Chinn, 2000; Kline, 2004), which is used to express an odds ratio on a scale comparable to effect sizes for continuous outcomes, such as Cohen's d. For an odds ratio OR:

$$\text{logit d}=\frac{\log(OR)}{\pi}\sqrt{3}\approx\frac{\log(OR)}{1.81}$$

The significance level was set at .05 for all analyses.

Results

Evolutions in the frequency of occurrence of RPT-groups' adoption of metacognitive regulation

Table 1 reveals that RPT-groups are predominantly involved in task execution (53.24%) and metacognitive regulation (43.55%), whereas only 3.21% of the time is spent on off-task behaviour. Table 2 (step 1) furthermore shows significant differences over time in the occurrence of metacognitive regulation. Compared to the intermediate phase, the odds of regulating are 0.84 times lower (p<.001) at the starting phase, whereas the odds are 1.12 times higher (p<.001) at the closing phase (small effect sizes *logit d*=-.10 and .07 respectively). Table 2 (step 2) moreover reveals a significant change in evolution rate (*factor* 0.86; p<.001) at RPT-session 6. From the first to the sixth RPT-session, the odds of regulating increase 1.08 times (p<.001) when shifting from one to the next RPT-session, whereas they are 0.93 times lower (p=.021) after RPT-session 6 (see Figure 2a).

The upward trend in RPT-groups' metacognitive regulation is not reflected during planning (see Table 1). No significant differences in planning are revealed when comparing the starting with the intermediate phase (p=.990), neither when comparing the intermediate with the closing phase (p=.422) (see Table 2 step 1). In contrast, RPT-groups orient considerably more frequently from the starting (4.71%) to the closing phase (11.20%), mainly due to enhanced activation of prior knowledge (see Table 1). Table 2 (step 1) moreover confirms significant differences over time in orientation. Compared to the intermediate phase, the odds of orienting are 0.46 times lower (p<.001) at the starting phase, whereas they are a 1.20 times higher (p=.005) at the closing phase (small effect size *logit d*=-0.43 and 0.10 respectively). Figure 2b further shows a different evolution pattern during the first and second intervention half, with a significant change in rate at RPT-session 4 (*factor* 0.73; p<.001). Whereas the odds of orienting are 1.40 times higher (p<.001) when shifting from one to the next RPT-session during the first intervention half, they do not change significantly after session 4 (*factor* 1.02; p=.576) (see Table 2 step 2).

Comparable evolutions are revealed for RPT-groups' evaluation. The latter increases from the starting (3.70%) to the closing phase (9.32%), due to enhanced evaluation of both learning outcomes and the learning process (see Table 1). Table 2 (step 1) moreover demonstrates significant differences over time in evaluation. Compared to the intermediate phase, the odds of evaluating are 0.54 times lower (p<.001) at the starting phase, whereas they are 1.46 times higher (p<.001) at the closing phase (small effect size *logit d*=-0.33 and 0.21, respectively). Figure 2c further depicts different evolution patterns during the first and second intervention half, with a significant change in rate at RPT-session 3 (*factor* 0.87, p=.011). From the first to the third RPT-session, the odds of evaluating increase 1.35 times (p<.001) when shifting from one to the next RPT-session, whereas they increase 1.17 times (p<.001) after RPT-session 3 (see Table 2 step 2).

Table 1. *Frequency of occurrence of metacognitive regulation in the RPT-groups during the three intervention phases (frequencies and percentages)*

Metacognitive regulation	Starting phase		Intermediate phase		Closing phase	
	frequency	*%*	*frequency*	*%*	*frequency*	*%*
Orientation	**145**	**4.71**	**402**	**9.74**	**869**	**11.20**
Task analysis	56	1.82	109	2.64	194	2.50
Exploring task demands	39	1.27	52	1.26	62	0.80
Processing task demands	17	0.55	57	1.38	132	1.70
Content orientation	60	1.95	288	6.98	654	8.43
Hypothesising	0	0	0	0	0	0
Activating prior knowledge	60	1.95	288	6.98	654	8.43
Awareness of task perceptions	29	0.94	5	0.12	21	0.27
Planning	**227**	**7.37**	**304**	**7.36**	**541**	**6.97**
Planning in advance	13	0.42	17	0.41	22	0.28
Formulating an action plan	13	0.42	15	0.36	22	0.28
Selecting an action plan	0	0	2	0.05	0	0
Interim planning	214	6.95	287	6.95	519	6.69
Formulating an action plan	205	6.65	276	6.68	455	5.86
Selecting an action plan	9	0.30	11	0.27	64	0.83
Monitoring	**2593**	**84.22**	**3150**	**76.31**	**5626**	**72.49**
Comprehension monitoring	1832	59.50	2274	55.09	3882	50.02
Noting lack of comprehension	48	1.56	35	0.83	40	0.51
Checking comprehension by repeating	1670	54.24	1770	42.89	2540	32.73
Checking comprehension by elaborating	114	3.70	469	11.37	1302	16.78
Monitoring of progress	731	23.75	758	18.36	1551	19.98
Checking progress	694	22.55	705	17.08	1381	17.79
Reflecting on progress	37	1.20	53	1.28	170	2.19
Monitoring of collaboration	30	0.97	118	2.86	193	2.49
Commenting on collaboration	30	0.97	118	2.86	188	2.42
Reflecting on collaboration	0	0	0	0	5	0.07
Evaluation	**114**	**3.70**	**272**	**6.59**	**723**	**9.32**
Evaluating learning outcomes	42	1.36	85	2.06	373	4.81
Checking learning outcomes	39	1.26	85	2.06	322	4.15
Elaborating on learning outcomes	3	0.10	0	0	51	0.66
Evaluating learning process	54	1.75	129	3.13	253	3.26
Commenting on learning process	51	1.65	78	1.89	172	2.22
Reflecting on learning process	3	0.10	51	1.24	81	1.04
Evaluating collaboration	18	0.59	58	1.40	97	1.25
Commenting on collaboration	18	0.59	58	1.40	71	0.92
Reflecting on collaboration	0	0	0	0	26	0.33
TOTAL	**3079**	**100**	**4128**	**100**	**7761**	**100**

Table 1 further demonstrates RPT-groups' dominant involvement in monitoring (especially comprehension monitoring) throughout the RPT-intervention. Despite an increase in the absolute frequency of occurrence of monitoring, Table 2 (step 1) reveals a significant negative evolution in RPT-groups' relative adoption of monitoring. Compared to the intermediate phase, the odds of monitoring are 1.65 times higher ($p<.001$) in the starting phase, whereas they are 0.81 times lower ($p<.001$) at the closing phase (small effect size *logit d*= 0.28 and -0.12 respectively). Figure 2d furthermore indicates a significant change in rate at RPT-session 3 (*factor* 1.22*;* $p<.001$). From the first to the third RPT-session, the odds of monitoring decrease 0.76 times ($p<.001$) when shifting from one to the next RPT-session, whereas they decrease 0.93 times ($p<.001$) after RPT-session 3 (see Table 2 step 2).

Table 2. *Time-bound evolutions in RPT-groups' metacognitive regulation behaviour (results of the analyses using mixed models for logistic regression)*

	STEP 1 - Evolutions over intervention phases[1]		**STEP 2 - Evolutions over 7 RPT-sessions, identifying change points**[2]			
	1st intervention half[3] **p-value logit d [95% CI]**[4]	**2nd intervention half**[5] **p-value logit d [95% CI]**	**change point**	**odds before change point**[6] **p-value logit d [95% CI]**	**odds after change point**[7] **p-value logit d [95% CI]**	**change in evolution rate**[8] **p-value**
Hypothesis 1 (evolutions in frequency of occurrence of key regulation skills)						
Metacognitive regulation	0.84 [0.79,0.89] p<.001 -0.10 [-0.13,-0.07]	1.12 [1.06,1.20] p<.001 0.07 [0.04,0.09]	session 6	1.08 [1.07,1.10] p<.001 0.04 [0.04,0.050]	0.93 [0.87,0.99] p=.021 -0.04 [-0.08,-0.01]	0.86 [0.80,0.92] p<.001
Orientation	0.46 [0.38, 0.56] p<.001 -0.43 [-0.54, -0.32]	1.20 [1.06, 1.35] p=.005 0.10 [-0.02, 0.12]	session 4	1.40 [1.30, 1.51] p<.001 0.19 [0.14, 0.23]	1.02 [0.96, 1.07] p=.576 0.01 [-0.02, 0.04]	0.73 [0.65, 0.81] p<.001
Task analysis	0.68 [0.49, 0.95] p=.021 -0.21 [-0.39, -0.03]	0.94 [0.75, 1.20] p=.643 -0.03 [-0.16, 0.10]	session 6	1.09 [1.01, 1.16] p=.022 0.05 [0.01, 0.08]	0.71 [0.51, 0.98] p=.035 -0.19 [-0.37, -0.01]	0.65 [0.45, 0.93] p<.001
Activation of prior knowledge	0.27 [0.20, 0.35] p<.001 -0.73 [-0.88, -0.57]	1.27 [1.09, 1.46] p=.001 0.13 [0.05, 0.21]	session 3	2.53 [2.05, 3.12] p<.001 0.51 [0.40, 0.63]	1.09 [1.04, 1.14] p<.001 0.05 [0.02, 0.07]	0.43 [0.43, 0.54] p<.001

[1] This column provides information on the change in odds of a particular regulation skill at a single segment when comparing the starting with the intermediate phase (i.e. first intervention half) and the intermediate with the closing phase (i.e. second intervention half), respectively.

[2] This column provides information on the change in odds of a particular regulation skill at a single segment when shifting from one RPT-session to the next RPT-session and indicates whether and at which RPT-session a significant change point (i.e. change in evolution rate) can be identified.

[3] This column presents evolutions in RPT-groups' metacognitive regulation from the starting to the intermediate phase. For each regulation skill, the change in odds at a single segment (i.e. factor and its corresponding 95% confidence interval on the first row), the significance of the evolution (i.e. p-value on the second row), and the effect size of the evolution (i.e. logit d and its corresponding 95% confidence interval on the third row) is presented.

[4] Logit d expresses an odds ratio on a scale comparable to effect sizes for continuous outcomes (e.g. Cohen's d). In line with Cohen's (1988) benchmark, logit d=.20 is considered as small, logit d=.50 as medium, and logit d=0.80 as a large effect.

[5] This column presents evolutions in RPT-groups' metacognitive regulation from the intermediate to the closing phase. For each regulation skill, the change in odds at a single segment (i.e. factor and its corresponding 95% confidence interval on the first row), the significance of the evolution (i.e. p-value on the second row), and the effect size of the evolution (i.e. logit d and its corresponding 95% confidence interval on the third row) is presented.

[6] This column presents evolutions in RPT-groups' metacognitive regulation over the 7 RPT-sessions. For each regulation skill, the change in odds at a single segment from RPT-session 1 to the subsequent RPT-session before the change point session (i.e. factor and its corresponding 95% confidence interval on the first row), the significance of the evolution (i.e. p-value on the second row), and the effect size of the evolution (i.e. logit d and its corresponding 95% confidence interval on the third row) is presented.

[7] This column presents evolutions in RPT-groups' metacognitive regulation over the 7 RPT-sessions. For each regulation skill, the change in odds at a single segment from the change point session to the subsequent session until RPT-session 7 (i.e. factor and its corresponding 95% confidence interval on the first row), the significance of the evolution (i.e. p-value on the second row), and the effect size of the evolution (i.e. logit d and its corresponding 95% confidence interval on the third row) is presented.

[8] This column presents the change in evolution rate before and after the change point (i.e. factor and its corresponding 95% confidence interval on the first row) and the significance of the evolution (i.e. p-value on the second row) for each regulation skill.

Planning	1.00 [0.84, 1.20] p=.990 0.00 [-0.10, 0.10]	0.92 [0.81, 1.09] p=.422 -0.03 [-0.11, 0.05]				
Monitoring	1.65 [1.46, 1.86] p<.001 0.28 [0.21, 0.34]	0.81 [0.74, 0.88] p<.001 -0.12 [-0.17, -0.07]	session 3	0.76 [0.70, 2.12] p<.001 -0.15 [-0.20, -0.11]	0.93 [0.90, 0.95] p<.001 -0.04 [-0.06, -0.03]	1.22 [0.11, 1.34] p<.001
Comprehension monitoring	1.19 [1.08, 1.31] p<.001 0.10 [0.04, 0.15]	0.81 [0.75, 0.87] p<.001 -0.12 [-0.16, -0.08]	session 2	0.82 [0.72, 0.93] p<.001 -0.11 [-0.18, -0.04]	0.94 [0.92, 0.96] p<.001 -0.04 [-0.05, -0.02]	1.14 [0.99, 1.31] p=.05
Monitoring of progress	1.38 [1.24, 1.55] p<.001 0.18 [0.12, 0.24]	1.11 [1.01, 1.22] p=.033 0.06 [0.01, 0.11]	session 4	0.89 [0.85, 0.93] p<.001 -0.06 [-0.09, -0.03]	1.04 [1.00, 1.09] p=.046 0.02 [0.00, 0.05]	1.17 [1.08, 1.27] p<.001
Monitoring of collaboration	0.33 [0.22, 0.50] p<.001 -0.61 [-0.83, -0.38]	0.87 [0.69, 1.10] p=.247 -0.08 [-0.20, 0.05]	session 4	1.68 [1.41, 1.99] p<.001 0.29 [0.19, 0.38]	0.94 [0.85, 1.04] p=.237 0.61 [-0.09, 0.02]	0.56 [0.44, 0.71] p<.001
Evaluation	0.54 [0.44, 0.68] p<.001 -0.33 [-0.46, -0.21]	1.46 [1.27, 1.68] p<.001 0.21 [0.13, 0.29]	session 3	1.35[1.17, 1.56] p<.001 0.17 [0.09, 0.25]	1.17 [1.12, 1.23] p<.001 0.09 [0.06, 0.11]	0.87[0.73, 1.03] p=.011
Evaluating learning outcomes	0.66 [0.45, 0.96] p=.029 -0.23 [-0.44, -0.02]	2.49 [1.96, 3.16] p<.001 0.50 [0.17, 0.63]	session 6	1.43 [1.33, 1.54] p<.001 0.20 [0.05, 0.28]	0.94 [0.74, 1.18] p=567 0.09 [0.06, 0.11]	0.65 [0.50, 1.96] p=.002
Evaluating learning process	0.57 [0.41, 0.78] p<.001 -0.32 [-0.49, -0.14]	1.06 [0.85, 1.31] p=.616 0.03 [-0.09, 0.15]	session 3	1.35 [1.10, 1.67] p=.004 0.17 [0.05, 0.28]	1.03 [0.96, 1.01] p=.473 0.02 [-0.03, 0.06]	0.76 [0.59, 0.97] p=.030
Hypothesis 2 (evolutions in deep-level metacognitive regulation)						
DL regulation	0.30 [0.26, 0.35] p<.001 -0.66 [-0.74, -0.56]	1.62 [1.48, 1.77] p<.001 0.27 [0.22,0.31]	session 4	1.88 [1.76, 1.99] p<.001 0.35 [0.31, 0.38]	1.11 [1.07, 1.15] p<.001 0.06 [0.04, 0.08]	0.59 [0.54, 0.65] p<.001
DL orientation	0.28 [0.21, 0.36] p<.001 -0.71 [-0.85, -0.57]	1.27 [1.11, 1.46] p<.001 0.13 [0.06, 0.21]	session 3	2.51 [2.08, 3.03] p<.001 0.51 [0.41, 0.61]	1.08 [1.03, 1.13] p=.001 0.04 [0.02, 0.07]	0.43 [0.35, 0.54] p<.001
DL activation of prior knowledge	0.27 [0.21, 0.35] p<.001 -0.73 [-0.88, -0.57]	1.27 [1.10, 1.46] p=.001 0.13 [0.05, 0.21]	session 3	2.53 [2.06, 3.21] p<.001 0.51 [0.40, 0.63]	1.09 [1.04, 1.14] p<.001 0.05 [0.02, 0.07]	0.43 [0.34, 0.54] p<.001
DL monitoring	0.37 [0.31, 0.45] p<.001 -0.54 [-0.65, -0.44]	1.61 [1.44, 1.79] p<.001 0.26 [0.20, 0.32]	session 4	1.87 [1.73, 2.02] p<.001 0.35 [0.30, 0.39]	1.09 [1.04, 1.14] p<.001 0.05 [0.02, 0.07]	0.58 [0.52, 0.66] p<.001
DL comprehension monitoring	0.32 [0.26, 0.39] p<.001 -0.63 [-0.74, -0.51]	1.56[1.39; 1.77] p<.001 0.25 [0.18, 0.31]	session 4	1.99 [1.83, 2.19] p<.001 0.38 [0.33, 0.43]	1.08 [1.03, 1.13] p=.002 0.04 [0.01, 0.07]	0.54 [0.48, 0.61] p<.001

Hypothesis 3 (evolutions in tutees' initiative for regulation)						
Tutee-initiated metacognitive regulation	0.70 [0.62, 0.79] p<.001 -0.19 [-0.26, -0.13]	1.40 [1.29, 1.53] p<.001 0.17 [0.14, 0.75]	session 6	1.11 [1.08, 1.14] p<.001 0.06 [0.04, 0.07]	1.69 [1.31, 1.86] p<.001 0.29 [0.15, 0.35]	1.52 [1.36, 1.71] p<.001
Tutee-initiated monitoring	0.79 [0.71, 0.90] p<.001 -0.12 [-0.19, -0.06]	1.27 [1.16, 1.40] p<.001 0.13 [0.08, 0.18]	session 6	1.06 [1.03, 1.09] p<.001 0.03 [0.02, 0.05]	1.60 [1.43, 1.78] p<.001 0.26 [0.20, 0.32]	1.50[1.33, 1.70] p<.001
Tutee-initiated deep-level metacognitive regulation	0.27 [0.19, 039] p<.001 -0.73 [-0.92, -0.52]	1.93 [1.62, 2.30] p<.001 0.36 [0.27, 0.46]	session 3	2.70 [2.00, 3.64] p<.001 0.55 [-0.45, 0.71]	1.32 [1.25, 1.40] p<.001 0.56 [0.12, 0.86]	0.49 [0.36, 0.68] p<.001
Tutee-initiated deep-level monitoring	0.33 [0.22, 0.49] p<.001 -0.61 [-0.83, -.39]	1.84 [1.50, 2.26] p<.001 0.34 [0.22, 0.45]	session 3	2.33 [1.69, 3.21] p<.001 0.47 [0.29, 0.64]	1.31 [1.22, 1.40] p<.001 0.15 [0.11, 0.19]	0.56 [0.40, 0.80] p=.001

Table 3. *Frequency of occurrence of low-level and deep-level metacognitive regulation in the RPT-groups during the three intervention phases (frequencies and percentages)*

Approach to regulation	**Starting phase**		**Intermediate phase**		**Closing phase**		**Total**	
	frequency	*%*	*frequency*	*%*	*frequency*	*%*	*frequency*	*%*
Low-level	**2757**	**91.69**	**3163**	**77.30**	**5212**	**67.71**	**11132**	**78.90**
Orientation	43	1.43	55	1.35	64	0.83	162	1.20
Planning	217	7.22	291	7.11	477	6.20	985	6.84
Monitoring	2389	79.45	2598	63.49	4108	53.37	9095	65.44
Evaluation	108	3.59	219	5.35	563	7.31	890	5.42
Deep-level	**250**	**8.31**	**929**	**22.70**	**2486**	**32.29**	**3665**	**21.10**
Orientation	76	2.53	344	8.41	786	10.21	1206	7.05
Planning	9	0.29	13	0.32	62	0.80	84	0.47
Monitoring	159	5.29	519	12.68	1478	19.20	2156	12.39
Evaluation	6	0.20	53	1.29	160	2.08	219	1.19

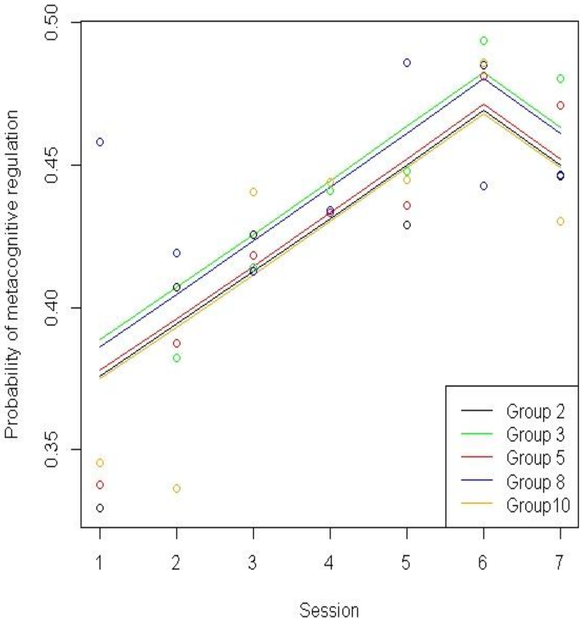

Figure 2a. Evolution in metacognitive regulation

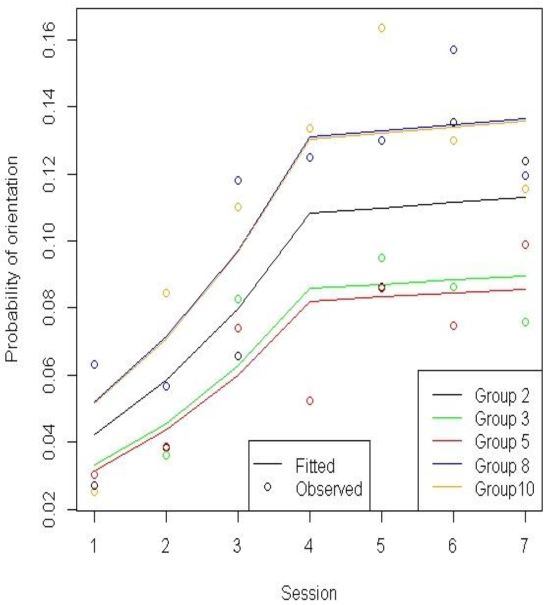

Figure 2b. Evolution in orientation

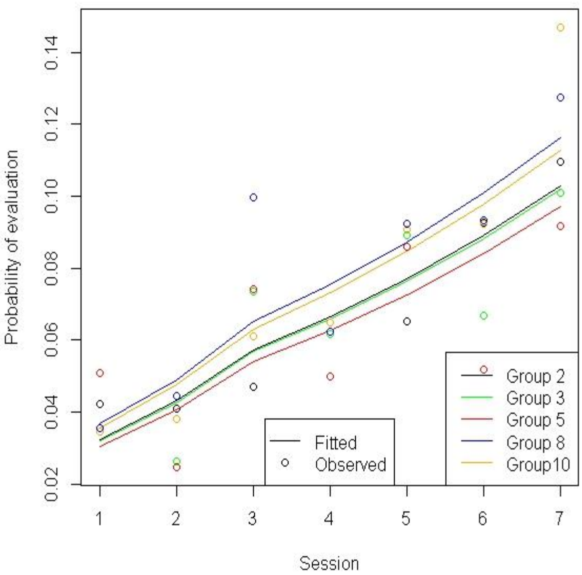

Figure 2c. Evolution in evaluation

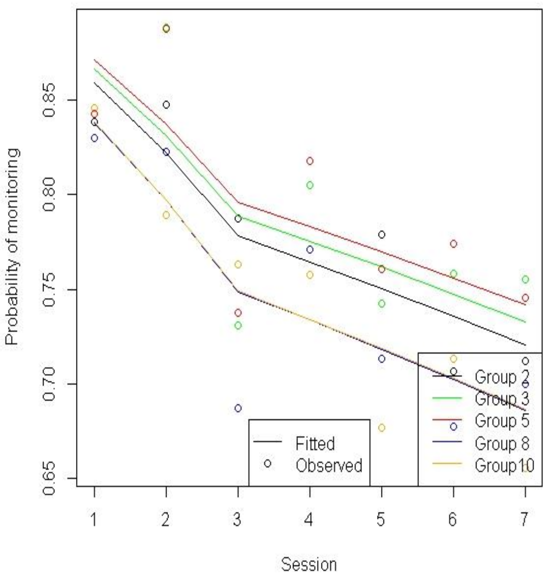

Figure 2d. Evolution in monitoring

Note: All figures in the chapter display the proportion of segments at which particular regulation behaviour occurs in function of session. The term "observed" refers to the observed proportions, whereas "fitted" refers to the fitted proportions that are obtained with logistic models allowing change points (see Table 2). Hence, the figures show the evolution in RPT-groups' adoption of particular regulation behaviour throughout the 7 RPT-sessions and indicate whether and at which session a significant change point (i.e. change in evolution rate) can be identified.

Evolutions in the approach to RPT-groups' metacognitive regulation

Whereas RPT-groups initially mainly apply low-level metacognitive regulation (see Table 3), they start adopting a deep-level approach more frequently at the intermediate (22.70%) and the closing phase (32.29%). Table 2 (step 1) confirms significant differences over time in deep-level regulation. Compared to the intermediate phase, the odds of deep-level metacognitive regulation are 0.30 times lower (p<.001) at the starting phase, whereas they are 1.62 times higher (p<.001) at the closing phase (moderate *logit d=* -0.66 and small effect size *logit d=0.27,* respectively). Figure 3a furthermore reveals a significant change in rate at RPT-session 4 (*factor* 0.59*, p*<.001). Whereas the odds of deep-level regulation increase 1.88 times (p<.001) when shifting from one RPT-session to the next during the first intervention half, they increase 1.11 times (p<.001) after RPT-session 4 (see Table 2 step 2).

The general trend towards deep-level regulation can, nevertheless, not be discerned for planning or evaluation (see Table 3). In contrast, RPT-groups increasingly adopt deep-level orientation from the starting (2.53%) to the closing phase (10.21%). Table 2 (step 1) also demonstrates significant differences over time: compared to the intermediate phase, the odds of deep-level orientation are 0.28 times lower (p<.001) at the starting phase (large effect size *logit d=*-0.73), whereas they are 1.27 times higher (p<.001) at the closing phase. Figure 3b further demonstrates a significant change in rate at RPT-session 3 (*factor* 0.43; p<.001). From the first to the third RPT-session, the odds of deep-level orientation increase 2.51 times (p<.001) when shifting from one to the next RPT-session, whereas they increase 1.08 times (p=.001) after RPT-session 3 (see Table 2 step 2), implying the evolution is especially large during the first RPT-sessions.

Whereas orientation becomes predominantly deep-level at the closing phase (see Table 3), RPT-groups mainly adopt low-level monitoring throughout the intervention, despite enhanced deep-level monitoring from the starting (5.29%) to the closing phase (19.20%). Table 1 shows that a deep-level approach is mainly used during comprehension monitoring. Table 2 (step 1) moreover reveals significant differences over time in RPT-groups' deep-level comprehension monitoring. Compared to the intermediate phase, the odds of deep-level comprehension monitoring are 0.32 times lower (p<.001) at the starting phase (moderate effect size *logit d*= -0.63) and 1.56 times higher (p<.001) at the closing phase. Figure 3c furthermore depicts a significant change in rate at RPT-session 4 (*factor* 0.54; p<.001). Whereas the odds of deep-level comprehension monitoring become 1.99 times higher (p<.001) when shifting from one to the next RPT-session during the first intervention half, they are 1.08 times higher (p=.002) after RPT-session 4 (see Table 2 step 2).

Evolutions in the initiative for RPT-groups' metacognitive regulation

RPT-groups' metacognitive regulation is dominantly initiated by the tutor (see Table 4). Although orientation, planning, and evaluation remain tutor-centred responsibilities as the RPT-intervention progresses, tutees take more initiative for monitoring from the starting (17.21%) to the closing phase (24.69%). Table 2 (step 1) moreover confirms significant differences over time in tutees' initiative for monitoring. Compared to the intermediate phase, the odds of tutee-initiated monitoring are 0.79 times lower (*p*<.001) during the starting phase, whereas they are 1.27 times higher (*p*<.001) during the closing phase (small effect sizes *logit d*= -0.12 and 0.13, respectively). Figure 4a furthermore indicates a significant change in rate at RPT-session 6 (*factor* 1.50; *p*<.001). From the first to the sixth RPT-session, the odds of tutee-initiated monitoring are 1.06 times higher (*p*<.001) when shifting from one to the next RPT-session, whereas they are 1.60 times higher (*p*<.001) after RPT-session 6, implying a larger evolution after this change point.

Despite tutees' initiative being mainly centred around low-level metacognitive regulation (see Table 5), tutee-initiated deep-level regulation (i.e. monitoring) significantly increases over time (see Table 2 step 1). Compared to the intermediate phase, the odds of tutee-initiated deep-level regulation are 0.33 times lower (*p*<.001) at the start (high effect size *logit d*= -0.73), whereas they are 1.84 times higher (*p*<.001) at the closing phase. Figure 4b furthermore demonstrates a significant change in rate at RPT-session 3 (*factor* 0.49; *p*<.001). From the first to the third RPT-session, the odds of tutee-initiated deep-level regulation increase 2.70 times (*p*<.001) when shifting from one to the next RPT-session, whereas they increase 1.32 times (*p*<.001) after RPT-session 3 (see Table 2 step 2).

Table 4. *Frequency of occurrence of tutor-initiated and tutee-initiated metacognitive regulation in the RPT-groups during the three intervention phases (frequencies and percentages)*

Initiative for regulation	Starting phase		Intermediate phase		Closing phase		Total	
	frequency	*%*	*frequency*	*%*	*frequency*	*%*	*frequency*	*%*
Tutor-initiated regulation	**1232**	**40.02**	**1463**	**35.44**	**2763**	**35.60**	**5458**	**37.02**
Orientation	80	2.60	177	4.29	396	5.10	653	4.00
Planning	198	6.43	217	5.26	357	4.60	772	5.43
Monitoring	879	28.55	938	22.72	1646	21.21	3463	24.16
Evaluation	75	2.44	131	3.17	364	4.69	570	3.43
Tutee-initiated regulation	**569**	**18.48**	**1009**	**24.44**	**2396**	**30.87**	**3974**	**24.60**
Orientation	23	0.75	56	1.36	145	1.87	224	1.33
Planning	14	0.46	54	1.31	102	1.35	170	1.04
Monitoring	530	17.21	855	20.71	1916	24.69	3301	20.87
Evaluation	2	0.06	44	1.06	230	2.96	276	1.36

Table 5. *Frequency of occurrence of tutee-initiated low-level and deep-level metacognitive regulation in the RPT-groups during the three intervention phases (frequencies and percentages)*

Approach to tutee-initiated regulation	Starting phase		Intermediate phase		Closing phase		Total	
	frequency	*%*	*frequency*	*%*	*frequency*	*%*	*frequency*	*%*
LL tutee-initiated regulation	**486**	**15.78**	**818**	**19.81**	**1756**	**22.63**	**3060**	**19.41**
Orientation	4	0.13	13	0.31	3	0.04	20	0.16
Planning	14	0.45	54	1.31	103	1.33	171	1.03
Monitoring	466	15.13	717	17.37	1471	18.95	2654	17.15
Evaluation	2	0.07	34	0.82	179	2.31	215	1.07
DL tutee-initiated regulation	**36**	**1.17**	**174**	**4.21**	**306**	**7.78**	**516**	**4.37**
Orientation	5	0.16	41	0.99	134	1.73	180	0.96
Planning	0	0	0	0	2	0.03	2	0.01
Monitoring	31	1.01	123	2.98	416	5.36	570	3.12
Evaluation	0	0	10	0.24	51	0.66	61	0.30

Note: LL= low-level; DL= deep-level

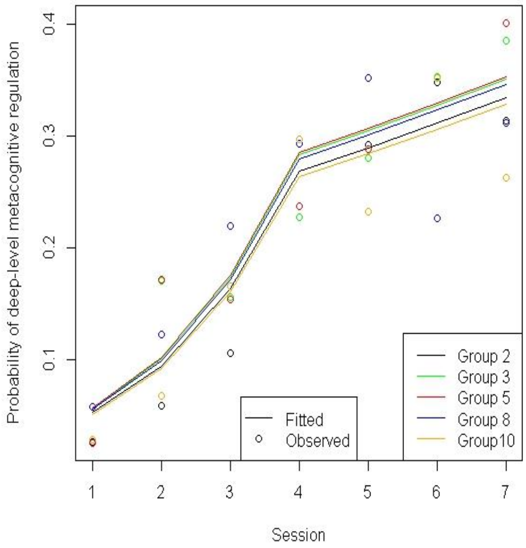

Figure 3a. Evolution in deep-level metacognitive regulation

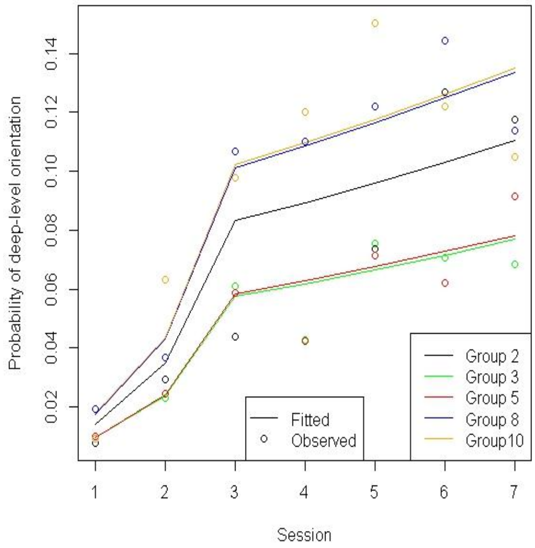

Figure 3b. Evolution in deep-level orientation

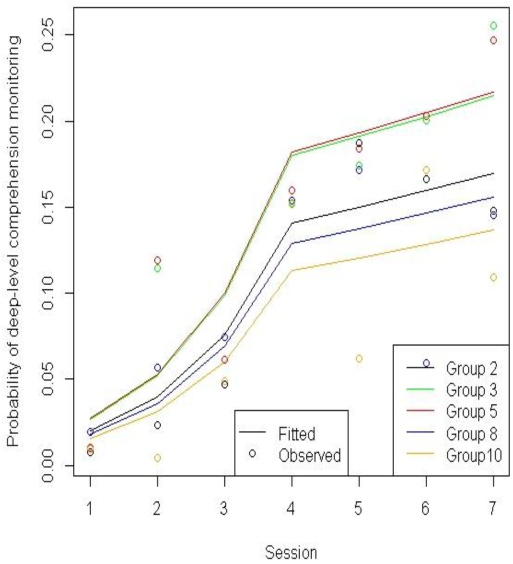

Figure 3c. Evolution in deep-level comprehension monitoring

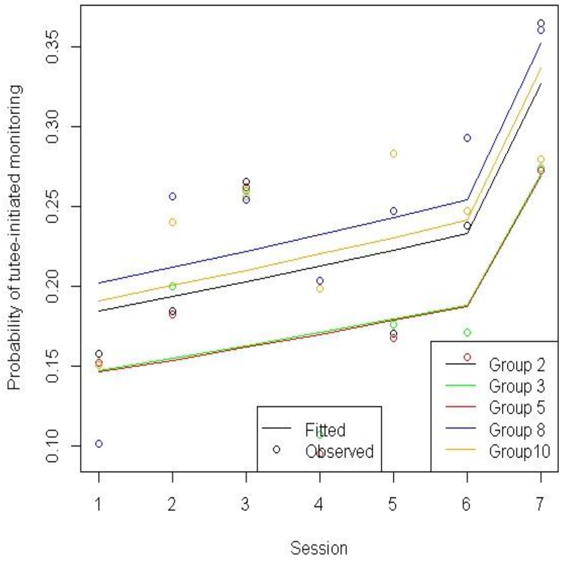

Figure 4a. Evolution in tutee-initiated monitoring

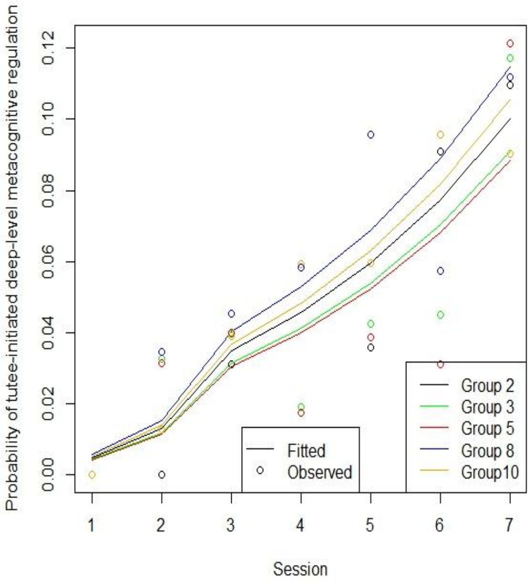

Figure 4b. Evolution in tutee-initiated deep-level regulation

Discussion

We aimed at investigating time-bound evolutions in RPT-groups' metacognitive regulation. More specifically, evolutions regarding (1) the frequency of occurrence of metacognitive regulation; (2) the approach to RPT-participants' regulation; and (3) the initiative for metacognitive regulation were analysed. By portraying collaborative learners' metacognitive regulation during a semester-long RPT-intervention, identifying differential evolution patterns related to learners' adoption of particular regulation skills and approaches, we advance the literature on metacognition in collaborative learning settings. Our micro-analytical process-oriented perspective on time-bound evolutions in metacognitive regulation behaviour extends prior work on metacognition in collaborative settings, which frequently concerns causal and output-related research. Additionally, we provide educators with valuable insights about when to prompt collaborative learners' adoption of or initiative for specific regulation strategies. The coding instrument developed for this study furthermore allows to capture collaborative learners' regulation behaviour in future studies focussing on other domains or different collaborative learning formats. Additionally, the instrument can help educators to gain insight in students' metacognitive regulation or provide them with cues when evaluating instructional interventions aimed at fostering particular regulation skills or approaches.

Evolutions in the frequency of occurrence of metacognitive regulation

Except for a relapse in the last RPT-session (probably connected to students' demanding agenda, with submission deadlines for multiple assignments and forthcoming exams in January, leading to enhanced off-task discussions at the end of the semester), RPT-groups' adoption of metacognitive regulation significantly increased throughout the intervention. Nevertheless, different evolution patterns were depicted for the separate regulation skills, revealing the need for differentiated scaffolding of collaborative learners' regulation skills.

The evolutions in RPT-groups' adoption of orientation and evaluation were most pronounced. This result might be due to the fact that the responsibility given to RPT-groups to solve a complex group assignment during a limited period of time, required them to orient themselves sufficiently, ensuring a common focus during conceptual peer discussions. Systematic engagement in the latter, might also have stimulated tutees to activate and share prior knowledge (Chi et al., 2001; King, 2002). Similarly, RPT might have required recurring evaluation of learning to ensure efficient problem solving with multiple students.

RPT-groups were further dominantly involved in comprehension monitoring. Since confronting students with each other's understanding challenged them to negotiate meaning and to engage in self-questioning (Chi et al., 2001; Kumpulainen & Kaartinen, 2003; Webb, 2009), the RPT-setting might have offered students a platform to train and optimise comprehension monitoring frequently. This was also reflected in the increased absolute frequency of occurrence of monitoring from the starting to the closing phase. However, since this increase was not as large as compared to RPT-groups' enhanced involvement in orientation and evaluation, a decrease in the probability of monitoring was revealed.

In contrast, RPT-groups' planning did not evolve significantly over time. Since task-specific characteristics of assignments partially determine the outcomes of collaborative learning (Perry & Winne, 2013; Pifarré & Cobos, 2010), the RPT-assignments might have been too structured for RPT-groups to be challenged into discussions about the selection and sequencing of problem solving steps. Their limited practice with planning might, in its turn, have prevented the internalisation of modelled planning by individual students, and consequently, the elicitation of additional planning by collaborating peers (Hadwin et al., 2005; Schunk & Zimmerman, 2007). Future research with different task formats (e.g. unstructured tasks or one major assignment to be solved over several RPT-sessions) could help to unravel whether and how collaborative learners' planning can be optimised.

The RPT-setting (i.e. collaborative learning in small groups and assigning a peer tutor who is expected to regulate the group's learning) allowed for intensive metacognitive modelling and individualised feedback on internalised regulation skills, which might have fostered students' adoption of metacognitive regulation. Nevertheless, potential alternative explanations should also be acknowledged. First, students' experienced need for self-regulation during their first semester at university should be taken into consideration (Bruinsma, 2004; Heikkilä & Lonka, 2006; Nota, Soresi, & Zimmerman, 2004). Having been acquainted with higher education's demands for self-management of one’s learning might have stimulated the development of regulation skills, which students subsequently demonstrated during the RPT-sessions. Second, the RPT-intervention was set up as a formal part of the course “Instructional Sciences”, that introduced students to theories about learning and instruction as well as to the topic of metacognition. Students’ enhanced domain-specific knowledge regarding the particular course content might have fostered their metacognitive regulation (Prins, Veenman, & Elshout, 2006; van der Stel & Veenman, 2010), resulting in theory-driven collaborative problem solving during the RPT-sessions. It might therefore be interesting to replicate the present study with RPT in a different course or another study domain. Third, the potential influence of the provided interim staff support (i.e. supervision and group-specific feedback sessions) should be acknowledged (Schraw et al., 2006; Veenman, van Hout-Wolters, & Afflerbach, 2006). Students’ engagement in self-reflections might have optimised both their tutoring behaviour and their metacognitive regulation skills. Fourth, since the order of the assignments could not be randomised across RPT-groups, due to the relatedness with the content of the lectures, students’ increased adoption of metacognitive regulation might have been partially determined by the structure, objectives, and content of the learning tasks (Iiskala et al., 2011; Perry & Winne, 2013). Although there are no indications that RPT-assignments in the early sessions of the RPT-intervention were less conductive for applying metacognitive regulation compared to assignments which were tackled in later RPT-sessions, future studies with different types of tasks could be relevant to rule out the possibility that the RPT-assignments in the present study might have been more decisive than the RPT-context itself. Last, students’ increased acquaintanceship of the RPT-sessions might have optimised their (regulation of) collaborative problem solving, for example due to enhanced familiarity with group members, which might have facilitated both positive socio-emotional interactions and group cohesion (Volet et al., 2009; Webb et al., 2006). Future studies preferably assess these process factors, aiming to filter out the specific contribution of RPT on students’ evolving regulation behaviour.

Evolutions in the deep-level approach to RPT-groups’ metacognitive regulation

Despite RPT-groups’ dominant involvement in low-level metacognitive regulation, they demonstrated deep-level regulation more frequently from the first intervention half onwards. This evolution was, however, only revealed for orientation and monitoring. Since extensive regulative practice facilitates the adoption of deep-level metacognitive regulation (Chin & Brown, 2000; Greene & Azevedo, 2007; Schunk & Zimmerman, 2007), tutors’ modelling of planning and evaluation might have been too limited or too implicit for RPT-groups to frequently adopt both regulation strategies, and subsequently evolve towards a deep-level approach. In contrast, tutors’ permanent questioning of tutees’ understanding probably served as direct metacognitive prompts, which might have fostered students’ activation of prior knowledge and (deep-level) comprehension monitoring. Furthermore, both collaborative learners’ deep learning (King, 1998; Roscoe & Chi, 2007) and highly interactive discussions (Goos et al., 2002; Iiskala et al., 2011; Molenaar, 2011) are related to their engagement in deep-level metacognitive regulation. It could be that highly interactive discussions and deep learning were especially demonstrated when students shared and compared their understanding to co-construct knowledge (e.g. when activating prior knowledge or monitoring comprehension). In contrast, planning and evaluation might have been characterised by quick consensus-building (Weinberger & Fischer, 2006), for example to ensure efficient problem solving, and might have therefore remained low-level by nature. Further research on the characteristics of RPT-groups' learning in relation to their approach to metacognitive regulation is needed.

Evolutions in tutees' initiative for RPT-groups' metacognitive regulation

Although tutees initiated monitoring significantly more frequently as they became familiar with the RPT-setting, we demonstrated in the present study that orientation, planning, and evaluation remained tutor-centred responsibilities. Since peer tutors generally tend to dominate the tutorial dialogues (Duran & Monereo, 2005; Graesser, Person, & Magliano, 1995; Roscoe & Chi, 2007), it was not surprising that they took the lead in initiating most of RPT-groups' regulation. Based on the literature (e.g. Hadwin et al., 2005; Rasku-Puttonen et al., 2003; Schmidt & Moust, 1998) one would, however, expect a stronger evolution from tutors' modelling to coaching for all regulation skills. More especially since the RPT-assignments were designed in a way that encouraged tutors to initially model and tutees to gradually adopt all key regulation skills. The results of the present study suggested, however, that tutees might need longer, more intensive metacognitive modelling (Hadwin et al., 2005; Schraw et al., 2006) or explicit scaffolding (Molenaar et al., 2010; Pifarré & Cobos, 2010; Rasku-Puttonen et al., 2003) to initiate RPT-groups' orientation, planning, and evaluation. Since those regulation skills could only be adopted at the start and upon completion of problem solving respectively (Meijer et al., 2006), the limited chances for tutors to model them might explain tutees' hesitation to initiate them. In contrast, tutors' frequent inquiries about tutees' understanding might have directly facilitated tutees' internalisation of and initiative for comprehension monitoring. Furthermore, students' perceptions of tutors' and tutees' responsibilities and status should be taken into consideration, since both are influential for students' engagement during PT (Colvin, 2007; Robinson, Schofield, & Steers-Wentzell, 2005). Tutors' responsibility towards the PT-group might have given them the status of decision-maker during orienting, planning, and evaluating, whereas tutees possibly perceived comprehension monitoring as a shared responsibility, given their experienced need to control their understanding when discussing with peers.

Additionally, it should be acknowledged that the quality of tutors' modelling might have been insufficient to consider tutors as good metacognitive models during orientation, planning, and evaluation (Hadwin et al., 2005; Schmidt & Moust, 1998). Since those regulation skills were less frequently adopted, as compared to monitoring, the chances for peer tutors to practice and refine their modelling of orientation, planning, and evaluation might have been more scarce.

The results further demonstrated that tutees' initiative for deep-level regulation remained limited. Possible explanations are in line with the abovementioned arguments for tutees' limited initiative for orientation, planning, and evaluation (e.g. few opportunities for tutees to internalise and implement deep-level regulation; insufficient modelling by tutors; the need for more explicit scaffolding, etc.) since the adoption of deep-level regulation requires intensive practice (Chin & Brown, 2000; Greene & Azevedo, 2007; Schunk & Zimmerman, 2007). Further, peer tutors might have intervened insufficiently when tutees started regulating the group's learning, not challenging them to adopt a deep-level approach. Future research on the metacognitive exchanges between tutor and tutees at the interpersonal level is needed to capture the interactional dynamics that might have prevented tutees' initiative for (deep-level) metacognitive regulation. Additionally, it would be interesting to examine whether tutees' adoption of deep-level regulation is related to tutors' evolving support from modelling to coaching (e.g. Did tutors model the deep-level approach from the beginning or only after tutees started initiating low-level regulation? Did tutors exclusively coach after tutees evolved towards initiating low-level regulation or did they take a step back, modelling deep-level regulation while coaching the low-level approach?).

Limitations of the present study and suggestions for future research

Despite adding interesting results to the research on metacognition in collaborative settings, the present study's limitations should also be acknowledged. First, the quantitative analysis of tutorial dialogue data provided rich and informative results, given the depth of coding. However, the time-consuming nature of this coding only allowed for data analysis of a relatively small sample (Roscoe & Chi, 2008; Volet, Vauras, Khosa, & Iiskala, 2013). The results of the statistical analyses should therefore be interpreted with caution, since they might not be representative for collaborative learning groups' metacognitive regulation in other (tutoring) settings. Finding a better compromise between sample size/representativeness and grain size of coding therefore remains a methodological challenge (Volet & Summers, 2013). In this respect, the use of semi-automated tools (e.g. Rosé et al., 2008) might be worth exploring. Furthermore, measures of RPT-groups' metacognitive regulation were exclusively based on students' verbalised metacognitive actions. It can be assumed, however, that students did not always explicitly articulate their thinking (Perry & Winne, 2013; Veenman et al., 2006; Vauras & Volet, 2013), implying that the identification of metacognitive regulation was not exhaustive for all regulative utterances during RPT. Additional coding of non-verbal communication could partially compensate for this (e.g. a student's frowned look could confirm researchers' interpretation of the student's unobservable comprehension monitoring thought) (Iiskala et al., 2011; Volet et al., 2013). However, since non-verbal gestures and expressions are not unambiguously interpretable (Perry & Winne, 2013; Roscoe & Chi, 2007; Veenman et al., 2006), data triangulation by means of additional stimulated recall interviews with tutors and tutees might be more preferable. This method could allow RPT-participants to express their intentions during collaborative learning, including their regulative thinking and actions, and therefore fully capture RPT-groups' metacognitive regulation.

Second, given that peer interactions are partially determined by the collaborative learning setting (Barron, 2003; Roscoe & Chi, 2008), future studies in other collaborative learning contexts (e.g.

smaller group size) or different PT-formats might be interesting, for they might reveal other evolutions and a differential adoption of metacognitive regulation. Although active participation might be higher and more intensive in dyads or triads compared to larger groups (Michinov & Michinov, 2009; Noroozi, Biemans, Weinberger, Mulder, & Chizari, 2013), the latter might invoke metacognitive regulation more frequently, given the larger communicative input of multiple peers eliciting reasoning and regulation (Webb, 2009). Additionally, cross-age peer tutors in fixed peer tutoring (i.e. in which tutor and tutee role taking by participants remains stable throughout the complete PT-intervention, Topping, 2005) might model metacognitive regulation more explicitly (Duran & Monereo, 2005), due to developmental differences in their metacognition (Molenaar, 2011). This could either facilitate tutees' initiative for regulation due to their increased metacognitive awareness (Schunk & Zimmerman, 2007), or rather hamper it due to PT-participants' perception of regulation being the responsibility of the more experienced tutor (Hadwin et al., 2005; Schmidt & Moust, 1998). Computer-supported PT might also unravel different regulative evolutions, given that online peer discussions are often short and non-reciprocal, aimed at reviewing instead of processing knowledge (Molenaar, 2011; Pifarré & Cobos, 2010).

Third, given the observation that collaborative learning is influenced by groups' and individual learners' characteristics (Chi et al., 2001; King, 2002; Molenaar, 2011; Volet et al., 2009; Webb, 2009), investigating the relation between RPT-groups' metacognitive regulation and those characteristics could be a promising future research direction, as these were not included in the present study. Measures of students' ability, motivational goal orientations, cognitive processing strategies, or groups' collaborative and reciprocal interactions (Goos et al., 2002; Pintrich, 2003; Roscoe & Chi, 2007; Volet et al., 2013; Weinberger & Fischer, 2006) might be interesting in this respect, since they might determine the opportunities to engage in metacognitive regulation. Further, assessing both individual students' domain-specific learning and their contributions to the RPT-discussions (e.g. through social network analysis, Hurme et al., 2006) could be a valuable future research direction. The former could provide insight in the importance of particular regulation strategies or approaches for students' learning, whereas the latter could unravel to what extent individual students participate in the peer discussions and contribute to the group's metacognitive regulation. Additionally, future studies on RPT-participants' commonly shared engagement in regulating the groups' learning are preferable, given that the quality and outcomes of social interactions during collaborative learning are determined by the level of interpersonal regulation among collaborative learners (Hadwin et al., 2011; Iiskala et al., 2011; Vauras & Volet, 2013). Studying tutors' and tutees' socially shared metacognitive engagement would furthermore help to fully understand how the evolutions in RPT-groups' metacognitive regulation revealed in the present study, were elicited and shaped through peers' interactions.

Fourth, it should be mentioned that although some evolutions in RPT-groups' metacognitive regulation were moderate to large (e.g. the adoption of deep-level orientation or tutees' initiative for deep-level monitoring), the results of the present study revealed rather small increases for the majority of the adopted regulation strategies. However, given the relatively short-term nature of the

RPT-intervention, even small evolutions in RPT-groups' regulation are important. Moreover, diverse evolutions were shown from the first intervention half onwards (e.g. the adoption of evaluation, deep-level orientation, tutee-initiated deep-level comprehension monitoring), implying that even a relatively short-term intervention is useful to train and optimise RPT-groups' metacognitive regulation. Investigating whether long-term and more intensive tutoring – though this would be related to different subjects – could establish larger and sustainable evolutions in RPT-groups' metacognitive regulation would therefore be an interesting future research direction.

Conclusion

Despite growing consensus on the potential of collaborative learning to adopt, train, and refine regulation skills, little is known about collaborative groups' metacognitive regulation. Since we provide an in-depth analysis of time-bound evolutions in RPT-groups' adoption of metacognitive regulation in the present study, we directly contribute to the scientific literature on metacognition in collaborative settings.

Generally, the results demonstrate that RPT-groups make significantly more frequent use of metacognitive orientation and evaluation throughout the RPT-intervention. Despite a dominance of low-level regulation, they additionally evolve towards significantly more deep-level orientation and monitoring as the RPT-intervention progresses. An evolution towards deep-level planning and evaluation is, however, not discerned. Furthermore, tutees initiate RPT-groups' monitoring significantly more as the RPT-intervention progresses, whereas orientation, planning, and evaluation remain tutor-centred responsibilities. The identification of critical change points regarding RPT-groups' adoption of regulation skills not only presents an innovative scope in the metacognition research, but also offers direct cues to foster groups' metacognitive regulation: insight in how and when regulation strategies are adopted by collaborative learners might give input to purposefully scaffold and optimise their metacognitive regulation. The introduction of the (low-/deep-level) approach to regulation equally adds to the research field, for it might encourage scholars studying metacognition to focus their future research not only on the frequency but also on the quality of regulation (Volet & Summers, 2013; Zimmerman & Schunk, 2011). Furthermore, the present study might serve as a starting point to investigate interpersonal regulation, an emerging research field faced with methodological challenges to capture and analyse shared regulation in collaborative groups (Hadwin et al., 2011; Vauras & Volet, 2013). Although it does not examine shared regulation among tutors and tutees at different levels of social interaction, the present study helps to identify multiple metacognitive regulation skills during collaborative learning, which might provide important input when theoretically refining and empirically capturing socially shared regulation during all cyclical phases of metacognitive regulation (Järvelä et al., 2013).

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Appendix A Overview of the RPT-intervention

week 1	tutor training	
week 2	training RPT-session	
week 3	RPT-session 1	(group-specific feedback groups 1, 3, 5, 7, 9, 11)
week 4	RPT-session 2	(group-specific feedback groups 2, 4, 6, 8, 10)
week 5	supervision session	
week 6	RPT-session 3	(group-specific feedback groups 1, 3, 5, 7, 9, 11)
week 7	RPT-session 4	(group-specific feedback groups 2, 4, 6, 8, 10)
week 8	RPT-session 5	(group-specific feedback groups 1, 3, 5, 7, 9, 11)
week 9	RPT-session 6	(group-specific feedback groups 2, 4, 6, 8, 10)
week 10	RPT-session 7	(group-specific feedback all groups)

Appendix B Examples of RPT-assignments

RPT-session 2: The epistemologic controversy and instructional behaviourism

Learning objectives

- Explaining the epistemologic controversy within instructional science.
- Situating the behaviouristic vision on learning and instruction within the epistemologic discussion.
- Explaining the basic principles of instructional behaviourism.
- Designing behaviouristic instruction activities and/or learning materials.

Introduction

In instructional science, an epistemologic discussion is going on about the meaning and the nature of knowledge. On the one hand, adherents of objectivism claim the absolute nature of knowledge. On the other hand, adherents of constructivism state that knowledge reflects personal experiences of the learner and stress the importance of individual knowledge construction based on these experiences. Both epistemologic viewpoints result in different visions on learning and instruction.

Part I: Familiarising with the terminology

Which of the following statements is correct? Explain and motivate your group's point of view.

(3) Instructional behaviourism is mainly based on the epistemology of objectivism.
(4) Instructional behaviourism focusses on active knowledge construction based on learners' personal interests.

Part II: Applying the terminology

An educational publisher is planning to bring a new biology handbook on the market, inspired by behaviouristic instructional principles. The target group for this handbook consists of first grade secondary school students. The publisher asks the help of your tutoring group to develop one chapter of this new handbook, in which one of the following themes can be presented: (1) the human body; (2) health care; (3) environmental care. The publisher expects your tutoring group to develop some behaviouristic learning materials and learning and instruction activities for this chapter. Consider potential behaviouristic teaching strategies, learning materials for the student, exercise materials, assignments for the students and the teachers. Attached you can find an excerpt from the national biology standards, that can give insight in the specific learning contents within each of the aforementioned themes.

RPT-session 7: The constructivist vision on learning and instruction

Learning objectives

- Explaining the basic principles of instructional constructivism.
- Recognising constructivist instructional practices in real-life cases.
- Explaining the concepts 'scaffolding', 'stolen knowledge', 'discovery learning', 'facilitator'.
- Designing constructivist learning materials.

Introduction

Instructional constructivism stresses the importance of active student participation during learning and instruction. This is related to the constructivist epistemologic point of view that knowledge is constructed based on learners' experiences in the learning environment. This implies the constructivist instructor should create a learning environment which challenges learners to explore and actively experiment with learning materials, in order to construct knowledge independently.

Part I: Familiarising with the terminology

Read the case in Appendix 1 and clarify whether you consider it an illustration of constructivist instruction. Explain and motivate your group's point of view.

Part II: Applying the terminology

M&P is an organisation which organizes mentoring programmes for primary and secondary school pupils who are at-risk due to their lower socio-economic background. M&P recruits students from higher education to voluntarily mentor the pupils at home. Before they can start as a mentor, all higher education students are expected to participate in a compulsory training on generic mentoring skills. M&P asks for your RPT-groups' advice on how to design such a mentor training based on the constructivist vision on learning and instruction. In other words, develop several instructional and learning activities to give input to the mentor training. Appendix 2 provides an overview of the mission of M&P, descriptions of the target groups (i.e. mentees and mentors) for the mentoring programmes, as well as an outline of themes which could be addressed during the mentor training (e.g. social-communicative styles; effective and efficient study approaches; didactic tools and learning activities; fostering parental involvement; establishing a safe and supportive learning environment; motivational strategies; individual learning styles).

Appendix C Coding instrument *"reciprocal peer tutoring groups' metacognitive regulation" (RPT_MCR)*

ORIENTATION		
Task analysis	Exploring task demands (LL)	*T:"I am the tutor of this session. Today we will discuss instructional behaviourism. I will read the introduction and the instructions out loud so that we all know what to focus upon."*
	Processing task demands/learning objectives (DL)	*T:"Okay, someone who can summarise the task instructions?"* *t1:"We have to state whether the theoretical statements are correct or not and also motivate why we think it is correct or what we would change about it to make it correct."* *t2: "So another learning goal... understanding all the theoretical concepts from the statements."*
Content orientation	Generating hypotheses (DL)	*t1: "Today we will discuss behaviouristic instruction. And we will have to illustrate instructional systems with real-life examples."* *t2: "How do you know?"* *t1: "Because of the title and the subtitles."*
	Activating prior knowledge (DL)	*T:"Last week we discussed the outlines of instructional behaviourism. Someone who remembers some of these outlines?"* *t1:"The instructor is fully responsible for the design of the learning process."* *t2:"Indeed! There is no active knowledge construction! (...) And learning materials are very structured, but I cannot remember the reason for that."* *t1: "Was it not because learners should make as few mistakes as possible?"*
Becoming aware of task perceptions		*t1:"The introduction is full of terminology that I have never heard of. I think we are facing a challenging tutoring session."* *t2: "Yes, this task also seems more difficult to me compared to the previous one."*
PLANNING		
Planning in advance	Formulating problem solving plan (LL)	*T: "We have 2 hours for this assignment, so I think we better make a planning. I suggest we work for 30 minutes on the first part of the assignment, about the statements. Then we will have more than an hour for designing the behaviouristic learning activities, the major part of the assignment."*
	Selecting problem solving plan (DL)	*T: "I don't know how we can best tackle this assignment. I can explain all the theoretical notions first and we solve all parts of the assignment afterwards . Or we can just start solving the assignment and I can explain specific theoretical notions whenever they are mentioned in the assignments and you don't understand them. What is most efficient according to you?"* *t1: "Or maybe you can start explaining the basics first, then we can start solving the task and when more detailed instructional systems are mentioned, you can explain them to us at that time."*
Interim planning	Formulating problem solving plan (LL)	*T: "That was the last statement of the orientation task. I suggest we immediately start with the second part. Who wants to read the instructions for the second part?"*

	Selecting problem solving plan (DL)	*T: "Can we move on to the next part? Because our time is limited."* *t1:"But we can first check if our answer to the first part is complete before we move on."* *t2:" Yes and it would also be good to explain the instructional systems once more before we start designing the learning materials."*
MONITORING		
Comprehension monitoring	Noting lack of comprehension	*T:"Does everyone understand the outlines of instructional behaviourism?"* *t1:"I still don't understand the concept of aptitude."*
	Checking comprehension by repeating (LL)	*T: "Does everyone agree now that instructional behaviourism and instructional constructivism are opposites?"* *t1: "I think (...) because in behaviourism the instructor decides on everything but constructivism is about learners being free to construct their own knowledge, right?"* *t2: "Yes constructivist learners are much more independent and active, not so?"*
	Checking comprehension by elaborating (DL)	*T: "The behaviouristic instructor permanently provides feedback. Who knows why?"* *t1: "Is it not to make sure that learners don't make mistakes?"* *t2: "Could that also be the reason why they structure the learning materials extensively? And why they don't like collaborative learning? Because collaborative learning requires spontaneous discussions between students. You cannot really structure it in advance, not so?"* *t1: "So our tutoring sessions are an illustration of constructivism and not behaviourism, right?"*
Monitoring of progress	Checking of progress (LL)	*t1: "We still have one hour for the last part of the task, so we are on schedule."* *T: "That's good. (...) Let me just double-check the meaning of mastery learning because I am not sure whether we interpreted it correctly when answering the statement about it."*
	Reflecting on progress (DL)	*t1: "It was a very good idea, tutor, to take time to explain the concepts first before discussing the correctness of the statements. Now we can tackle the statements much more efficiently!"* *t2: "I agree! It would even be wise to make this approach our standard approach in our future tutoring sessions."*
Monitoring of collaboration	Commenting on collaboration (LL)	*T: "I like the working spirit today! Especially that everyone is participating in the discussions. This is true group work, tutees!"*
	Reflecting on collaboration (DL)	*t1: "The theory is quite challenging today but you explain it very well, tutor. You took time to prepare yourself for this session, not so?* *T: "Yes, I studied the theory and made brief overviews of the instructional systems. It was time-consuming to get familiar with the terminology but now I feel confident to tutor this session."* *t2: "I will be the tutor next week and I planned to read the handbook, but I can see the advantage of a more extensive preparation. You inspired me, tutor!"*

EVALUATION		
Evaluating learning outcomes	Checking learning outcomes (LL)	*T: "We completed the task, not so? We designed two chapters for the behaviouristic handbook, that is enough." t1: "Yes and we included many concrete illustrations." t2: "That is good, because they specifically asked for that in the task instructions."*
	Elaborating on learning outcomes (DL)	*T: "Before ending this session I would like us to check if the answers we provided address the topics which are mentioned in the learning objectives." t1: "Is that important?" T: "I think it might help us to evaluate whether our answers meet the expectations. If learning objectives are not reflected in our answers it indicates that we did not cover all the theory in our discussions and in our answers to the subtasks.(...) Who wants to reread the learning objectives?"*
Evaluating learning process	Commenting on learning process (LL)	*T: "I think this was a good tutoring session. At the start, we advanced with difficulty because my questions remained frequently unanswered, but halfway the session there was full cooperation from everyone, which increased our productivity. Does everyone agree?"*
	Reflecting on learning process (DL)	*T: "Any evaluative remarks about this session?" t1: "The tutor's outline of instructional systems which was written down on the whiteboard really helped to keep the overview." t2: "Not only that! I also have the feeling that we studied the theory more profoundly. Because this overview directly challenged us to inquire about the differences between the systems in more detail. I'm in favour of using this approach more frequently!"*
Evaluating collaboration	Commenting on collaboration (LL)	*t1: " This was the third session and I have the impression that we're more at ease with each other now. It helps to succeed in tutoring."*
	Reflecting on collaboration (DL)	*T: "I would like to get some feedback on my tutorship. Is there something I could have done better or differently?" t1: "I enjoyed having you as a tutor, because you could explain all concepts clearly. It was also good that you frequently checked whether our answers were complete." t2: "I agree on that one, but it would have been good to check on the time as well. Because we took too long to finish the introductory part and there was no time to discuss the theory in detail." t1: "Maybe we can appoint someone next week to check the time during the session?"*

Note: LL= low-level; DL=deep-level ; T=tutor; t=tutee

Although RPT-groups' metacognitive statements were coded at the turn level, the illustrations in the coding instrument represent episodes of metacognitive regulation. We opted for illustrative episodes because statements mainly gain their metacognitive nature by considering them in combination with other statements, whereas isolated statements may not necessarily reflect metacognitive regulation (Volet et al., 2013).

Appendix D Illustration of the two-step coding procedure

Excerpt of RPT-discussion	Coding at episode level (step 1)	Coding at turn level (step 2)
T: "During peer assessment students correct each other and construct knowledge. So the statement is incorrect, behaviourism is not about active knowledge construction."	Task execution	
t1: "So peer assessment never occurs in behaviourism?" Because you can also give evaluation criteria, to make it structured, not so?"	Metacognitive regulation	Monitoring_comprehension monitoring (DL) tutee-initiative
t2: "Yeah and behaviourism promotes structured learning materials, right?"		Monitoring_comprehension monitoring (LL)
T: "It is correct that behaviourism promotes structured learning materials because students should not make incorrect interpretations. But in the statement, peer assessment is not limited to the outcomes, also the process is included."	Task execution	
T: "And what do you still remember about behaviourism and the learning process?"	Metacognitive regulation	Orientation_prior knowledge activation (DL) tutor-initiative
t4: "Interested in marking outcomes but not in the thinking that led to those outcomes, if I remembered well. Not so?"		Orientation_prior knowledge activation (DL)
t5: "So that is the teacher as guiding practitioner, right?"		Monitoring_comprehension monitoring (DL) tutee-initiative
t5: "I think it's important to stick to the statements and not to add information or start assuming like now."	Metacognitive regulation	Monitoring_progress monitoring (LL) tutee-initiative
T: "Yes, let's keep that in mind. What have we written so far? Can you read our answer please?"		Monitoring_progress monitoring (LL)
t4: "I typed that the statement is incorrect, behaviourism is not about active knowledge construction neither focusses on the learning process. And those are two elements that characterise peer assessment."	Task execution	

Note: T= tutor; t= tutee; LL= low-level; DL=deep-level

5 Exploring evolutions in reciprocal peer tutoring groups' socially shared metacognitive regulation and identifying its metacognitive correlates

This chapter is based on:

De Backer, L., Van Keer, H., & Valcke, M. (2015). Exploring evolutions in reciprocal peer tutoring groups' socially shared metacognitive regulation and identifying its metacognitive correlates. *Learning and Instruction, 38,* 63-78.

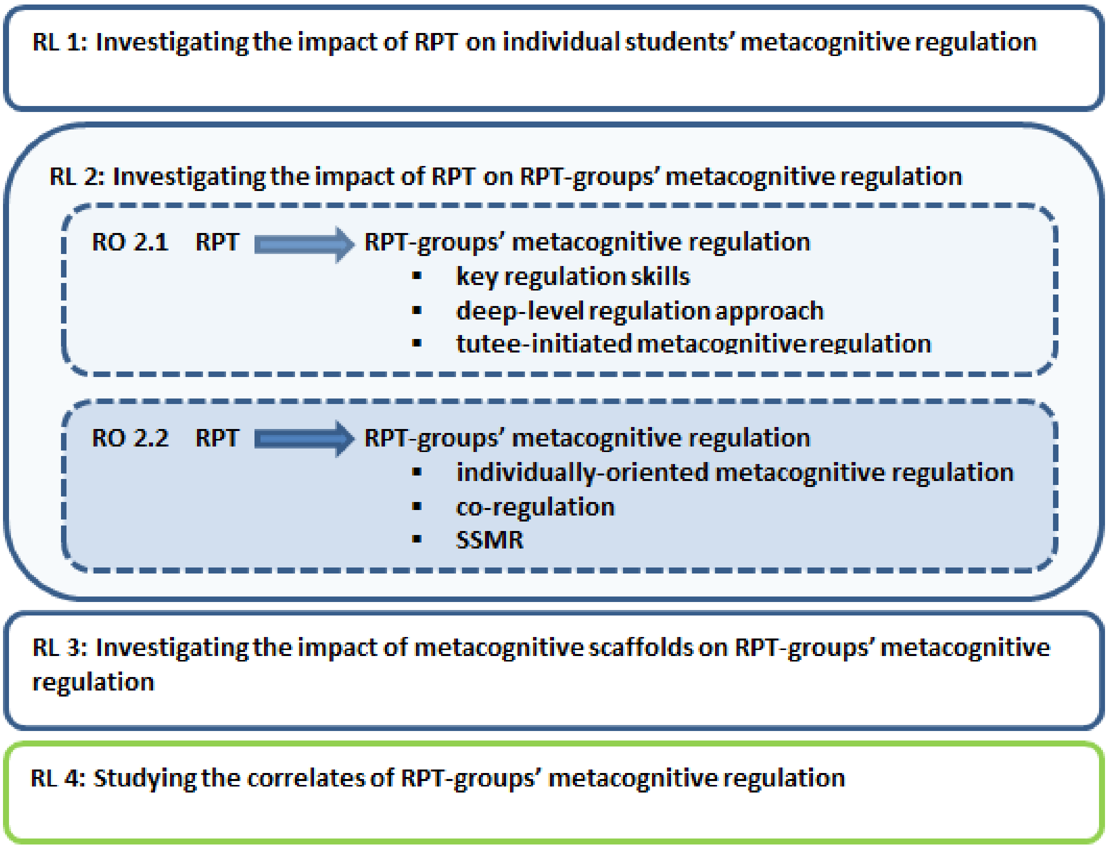

*Figure 1***.** Chapter 5 in relation to the research lines of the dissertation

Chapter 5

Exploring evolutions in reciprocal peer tutoring groups' socially shared metacognitive regulation and identifying its metacognitive correlates

Abstract

The present study contributes to the emerging research on socially shared metacognitive regulation (SSMR). It investigates which regulation behaviour (i.e. particular skills and low- versus deep-level regulation) is associated with a socially shared regulation focus and identifies time-bound evolutions in individually-oriented metacognitive regulation, co-regulation, and SSMR. More specifically, higher education reciprocal peer tutoring (RPT) groups are studied. All sessions of a semester-long RPT-intervention of five randomly selected RPT-groups were videotaped (70h of recordings). Time-bound evolutions are studied by means of mixed models for logistic regression analysis allowing change points, whereas binary logistic regressions are used to examine the relation between RPT-groups' socially shared regulation focus and their regulation skills and approaches. The results indicate that RPT-groups demonstrate a significant positive evolution in SSMR and tutee-prompted co-regulation, and a significant negative evolution in tutor-prompted co-regulation. Their socially shared regulation focus is particularly correlated with orientation, monitoring, and deep-level regulation.

Introduction

New perspectives on metacognition centre on peers' social interactions during collaborative learning as contextual facilitators when fostering metacognitive regulation (Hadwin, Järvelä, & Miller, 2011; Vauras & Volet, 2013). Conceptual peer discussions, shared knowledge construction, and joint problem solving prompt students to reflect upon their comprehension and to coordinate the collaborative learning process, directly addressing their metacognitive regulation. Collaborative learning groups should, however, not only be considered as facilitative contexts to model, internalise, train, and refine one's metacognitive regulation, they also represent unique social systems, eliciting regulation activities at different levels of social interaction (Iiskala, Vauras, Lehtinen, & Salonen, 2011; Järvelä, Järvenojä, Malmberg, & Hadwin, 2013). During collaborative learning, one peer can, for example, take a more instructive role to guide the metacognitive regulation of another peer, resulting in co-regulation of learning (Grau & Whitebread, 2012; Hadwin, Wozney, & Pontin, 2005; Volet, Summers, & Thurman, 2009a). Furthermore, multiple collaborating peers can jointly assume responsibility for the group's learning and interdependently regulate the collaborative learning process towards shared learning goals (Iiskala et al., 2011; Järvelä et al., 2013;

Rogat & Linnenbrink-Garcia, 2011). Such socially shared metacognitive regulation (SSMR) is considered the most profound mode of social regulation (Hadwin et al., 2011; Vauras & Volet, 2013) and contributes to an important extent to successful collaborative learning (Iiskala et al., 2011; Volet, Vauras, & Salonen, 2009b). Despite growing consensus about the importance of SSMR, research regarding collaborative learners' regulation at the interpersonal level is limited and mainly focusses on either empirically validating the differentiation between self and social forms of metacognitive regulation (e.g. Grau & Whitebread, 2012; Iiskala et al., 2011; Volet et al., 2009a), or unfolding the methodological challenges encountered when identifying episodes of SSMR (e.g. Perry & Winne, 2013; Vauras & Volet, 2013). The present study extends prior research by investigating whether particular metacognitive regulation skills and low- versus deep-level approaches to regulation stimulate/hamper collaborative learning groups' adoption of a socially shared focus when regulating their learning. More specifically, the metacognitive regulation behaviour of reciprocal peer tutoring (RPT) groups in higher education is studied. Additionally, this study provides an in-depth analysis of time-bound evolutions regarding RPT-groups' adoption of individually-oriented metacognitive regulation, co-regulation, and SSMR. By unravelling the correlates of RPT-groups' SSMR and portraying developmental data on how SSMR unfolds over time, the current study provides an innovative scope in the metacognition research (Molenaar & Järvelä, 2014; Perry & Winne, 2013; Volet et al., 2009b).

Theoretical underpinnings

Metacognitive regulation and collaborative learning

Metacognitive regulation refers to a set of self-regulatory skills and strategies which are used by students to actively control, coordinate, and regulate their learning (Hadwin et al., 2011; Meijer, Veenman, & van Hout-Wolters, 2006). Metacognitive regulation activities can be focussed on one's own, a collaborating peer's, or a collaborative learning group's learning process, depending on the regulative agents involved and their underlying intentions (Lajoie & Lu, 2012; Rogat & Adams-Wiggins, 2014; Volet et al., 2009a). Intrinsically, metacognitive regulation concerns a highly idiosyncratic process, guided by individual learning goals and one's personal learning experiences (Brown, 1987; Hadwin et al., 2011; Schunk & Zimmerman, 2007). Nevertheless, collaborative learning contexts also invite students to collectively undertake regulation activities by projecting and transferring this individual process to other students, creating an opportunity to demonstrate metacognitive regulation at a social level (Grau & Whitebread, 2012; Hadwin et al., 2011; Molenaar & Järvelä, 2014). The present study conceptualises collaborative learning as a student-activating instructional approach, in which multiple peers or people from similar social groupings who are not professional teachers, academically work together towards a common goal (Dillenbourg, 1999; Johnson & Johnson, 1999; Topping, 2005). Particular forms of social interaction, such as asking questions, conceptually discussing learning content, providing feedback, explaining, and collectively making decisions, encourage students' active and purposeful acquisition of knowledge and skills (Hurme, Palonen, & Järvelä, 2006; King, 1998; Roscoe & Chi, 2008). Merely putting students together does, however, not guarantee successful collaboration (Dillenbourg, 1999). In contrast, maximising one's own and each other's learning requires (a) positive interdependence or peers' mutual contributions to group interactions, making students aware that peers' help is needed to achieve learning objectives; (b) individual accountability, which ensures that each collaborative learner is responsible for one's own learning and for helping peers to learn; (c) direct interactions through which collaborative learners facilitate each other's efforts to complete the academic task and achieve the group's goals; (d) social skills, which allow students to adequately interact with peers in a way that promotes communication, respectful and productive negotiation, and positive socio-emotional relations; and (e) evaluative judgements on group processes, which foster students' reflections on their own and each other's learning, aimed at optimising future collaboration (Barron, 2003; Dillenbourg, 1999; Johnson & Johnson, 1999). The open learning environment in which collaborative learners operate, additionally requires them to discuss the organisation and permanently control and coordinate their collective learning process and the joint problem solving steps they undertake (Hurme et al., 2006; Iiskala et al., 2011). In other words, successful collaborative learning also demands for and, up to some level, naturally elicits students' adoption of metacognitive regulation skills.

Metacognitive regulation skills and approaches

We distinguish orienting, planning, monitoring, and evaluating as key metacognitive regulation skills (Brown, 1987; Veenman, Elshout, & Meijer, 1997). When orienting, students engage in task analysis, which might result in becoming aware of one's task perceptions or activating one's prior knowledge (Butler, 2002; Meijer et al., 2006). Planning encompasses selecting and sequencing problem solving strategies and developing action plans (Meijer et al., 2006). Monitoring involves quality control of one's learning or problem solving, aimed at identifying inconsistencies and at optimising task execution (Meijer et al., 2006; Webb, 2009). Comprehension monitoring refers to control activities focusing on the correctness of one's understanding (Hurme et al. 2006; King, 1998); monitoring of progress focusses on the adequateness of problem solving strategies or the quality of perceived progress (Veenman et al., 1997); whereas monitoring of collaboration is directed at individuals' participation or role taking and the collaboration in the group (King, 1998). Finally, evaluation involves learners' self-judgment upon completion of problem solving (Veenman et al., 1997). This can be directed at the learning outcomes, the problem solving process, or the group members' collaboration[1] (Butler, 2002; Meijer et al., 2006).

Given that collaborative learners' metacognitive regulation is linked to their lower versus higher-order content processing and their approach to learning (King, 1998; Roscoe & Chi, 2008; Volet et al.,

[1] It should be noted that both monitoring of collaboration and evaluation of collaboration are only applicable in collaborative learning situations.

2009a), we distinguish low-level and deep-level metacognitive regulation (De Backer, Van Keer, & Valcke, in press b). Low-level orientation is directed at exploring task demands, whereas deep-level orientation aims at processing task demands and activating prior knowledge (Butler, 2002). Low-level planning implies the development of a single action plan for problem solving, whereas deep-level planning involves selecting an approach from problem-solving alternatives (Meijer et al., 2006; Veenman et al., 1997). When students check the group's progress, collaboration, or their own or peers' understanding, they engage in low-level monitoring. Reflective comments on the quality of the group's collaboration or perceived progress and elaborative, thought-provoking inquiries imply deep-level monitoring (Chin & Brown, 2000; Roscoe, 2014). Correspondingly, low-level evaluation involves checking and commenting on either learning outcomes or process factors, whereas deep-level evaluation implies reflective judgements on both (Veenman et al., 1997).

Deep-level metacognitive regulation generally advances students' learning. Students adopting a deep-level regulation approach demonstrate profound conceptual understanding and higher levels of cognitive engagement, aimed at elaboration and meaning making (Chin & Brown, 2000; Khosa & Volet, 2014; Volet et al., 2009b). Additionally, their deep-level regulation approach benefits their learning outcomes (Rogat & Adams-Wiggins, 2014).

The social dimension in metacognition research

Traditionally, metacognitive regulation has been conceptualised and studied from an individual perspective (Grau & Whitebread, 2012; Hadwin et al., 2011; Iiskala et al., 2011). Prior research aimed at understanding processes individual learners adopt to regulate personal learning. The growing attention paid to collaborative learning in educational research, pushed the attention to the social context in which learners apply metacognitive regulation (Perry & Winne, 2013; Vauras & Volet, 2013; Volet et al., 2009b). However, this research focus on integration of the social context varies considerably (Grau & Whitebread, 2012; Rogat & Linnenbrink-Garcia, 2011). It ranges from conceptualising collaborative learning as a supportive learning environment promoting metacognitive regulation to considering metacognitive regulation as an intrinsically shared activity among collaborative learners (Hadwin et al., 2011; Järvenoja, Volet, & Järvelä, 2013; Volet et al., 2009b). During collaborative learning students feel the need to regulate interactions and learning processes, for they have to discuss and agree upon "what" as well as "how" they learn (Hurme et al., 2006; King, 1998). Since individual regulatory contributions elicit new regulative actions from collaborating peers (Hurme et al., 2006; Iiskala et al.,2011), collaborative learning provides multiple opportunities to practice and optimise one's metacognitive regulation. Despite acknowledging the reciprocal influence between individual learners and the social context in a collaborative learning setting, this perspective still primarily considers metacognitive regulation as an individual phenomenon (Hadwin et al., 2011; Rogat & Linnenbrink-Garcia, 2011). A collaborative learning group should, however, also be conceptualised as a social system (Iiskala et al., 2011; Khosa & Volet, 2014; Volet et al., 2009b), which is not equal to multiple self-oriented agents being inspired to regulate by their peers. Successful collaborative learning requires students to engage in collaborative goal setting, to control each other's comprehension and to collectively regulate their group's learning, implying shared metacognitive regulation at the interpersonal level (Hadwin et al., 2011; Järvelä et al., 2013; Perry & Winne, 2013). Although effective forms of interpersonal regulation can be facilitated by providing students with interactive learning tools (Lajoie & Lu, 2012; Saab, van Joolingen, & van Hout-Wolters, 2012), interdependently regulating the collective learning process remains challenging and needs time to develop (Molenaar & Järvelä; 2014; Perry & Winne, 2013; Volet et al., 2009b). Consequently, interpersonal regulation cannot automatically be established when peers learn collaboratively. Rather, various regulative foci can be distinguished at different levels of social interaction, ranging from individually-oriented metacognitive regulation over co-regulation, to fully shared metacognitive regulation towards joint learning objectives (Hadwin et al., 2011; Järvelä et al., 2013; Volet at al., 2009a).

Individually-oriented, co-regulated, or socially shared metacognitive regulation

Despite taking part in collaborative learning, students might primarily feel responsible for their personal learning, resulting in individually-oriented metacognitive regulation[2] (Grau & Whitebread, 2012; Hadwin et al., 2011). This encompasses adoption of regulatory skills aimed at optimising one's personal understanding and progress during collaborative problem solving (Järvelä et al., 2013; Saab et al., 2012). Individually-oriented metacognitive regulation is consequently based on intra-individual learning goals and feedback-loops, whereas peers are merely considered as metacognitive models who are inspirational to refine one's own metacognitive regulation (Hadwin et al., 2011).

Collaborative learning provides opportunities to engage in metacognitive regulation with one or more peers. Depending on the level of reciprocity within joint regulative actions, we distinguish (asymmetrical) metacognitive co-regulation and (mutual) socially shared metacognitive regulation (Iiskala et al., 2011; Järvenojä et al., 2013; Volet et al., 2009b). Metacognitive co-regulation is characterised by one student assuming responsibility for regulating another peer's or the group's learning (Grau & Whitebread, 2012; Hadwin et al., 2005). It is demonstrated when one student directly instructs, scaffolds, or prompts collaborating peers into metacognitive regulation, resulting in an unequal distribution of metacognitive engagement among collaborative learners (Järvelä et al., 2013; Perry & Winne, 2013; Volet et al., 2009a). During metacognitive co-regulation the instructing student's regulative actions are guided by intra-individual goals but focussed on and aimed to sustain/correct another student's metacognitive activity (Volet et al., 2009b). The role of co-regulator can shift among learners and across time, depending on their varying expertise and related need to be assisted or to provide assistance to regulate, as collaborative learning progresses (Perry & Winne,

[2] We opt for the term "individually-oriented metacognitive regulation" to stress the present study's focus on metacognitive regulation directed at the individual student's learning. This should, however, not be equated with self-regulated learning (SRL), since the latter is conceptualised as a learner's deliberate monitoring, regulation, and control of one's cognition, motivation, and behaviour towards the completion of an academic goal (Hadwin et al., 2011). SRL therefore encompasses a metacognitive, cognitive, and motivational component, whereas the present study exclusively focusses on metacognitive regulation.

2013). Previously, co-regulation has mainly been conceptualised as a transitional process towards self-regulation: a temporary phase during which a supportive student models and prompts particular regulation behaviour that another student is capable of but does not engage in spontaneously (e.g. DiDonato, 2013; Hadwin et al., 2005). Experiencing and reflecting upon the co-regulator's regulative prompts is, in this respect, expected to facilitate the supported student's self-regulation. Although direct metacognitive peer support might promote an individual student's metacognitive regulation, the present study broadens prior literature's conceptualisation of co-regulation, by acknowledging the latter as a specific form of metacognitive regulation along the social spectrum (Rogat & Adams-Wiggins, 2014; Volet, Vauras, Khosa, & Iiskala, 2013).

The highest level of interpersonal regulative engagement is found in socially shared metacognitive regulation (SSMR) (Hadwin et al., 2011; Vauras & Volet, 2013). It concerns a collectively assumed responsibility for regulation among multiple collaborative learners (Iiskala et al., 2011; Grau & Whitebread, 2012; Rogat & Linnenbrink-Garcia, 2011). Although initiated by individual students, SSMR is characterised by subsequent involvement in metacognitive regulation of collaborating peers reciprocally operating on each other's regulative acts in a spiral-like process (i.e. one student's regulative acts are referred to in another student's regulative acts, which elicit subsequent regulative acts from a third student involved in the same regulation skill, who's regulative acts refer to both the first and the second student's contributions and in their turn elicit reciprocal regulative acts from (yet) another student, etc.). Consequently, SSMR is based on interpersonal regulative feedback loops and directed by a collectively negotiated understanding of group level activities (Volet et al., 2009b). SSMR occurs when students co-construct task representations, share learning goals, shape the collaborative problem solving process by reciprocally monitoring each other's comprehension and the group's progress, and collaboratively reflect upon the group's learning activities and outcomes (Hadwin et al., 2011; Järvelä et al., 2013; Perry & Winne, 2013). Therefore, SSMR implies shared metacognitive awareness and egalitarian, interdependent adoption of regulation skills towards joint learning objectives in groups operating as genuine social entities (Saab et al., 2012; Volet et al., 2009b).

Since collaboration is conceptualised as a process in which participants are committed to collective problem solving and shared understanding through interaction with others, aimed at a common objective (Järvelä et al., 2013; Rogat & Adams-Wiggins, 2014), it should not be surprising that successful collaborative learning is related to learners' coordinated and mutual engagement in regulating the group's problem solving (Iiskala et al., 2011; Lajoie & Lu, 2012; Volet et al., 2009a). Adopting SSMR results in better group performance (Chan, 2012; Järvelä et al., 2013), as well as in increased reflection on and understanding of individual students' mental models and problem solving strategies (Chan, 2012; Iiskala et al., 2011; Lajoie & Lu, 2012). By promoting reflection, SSMR can enhance students' ability to effectively self-regulate their personal learning, benefitting their academic performance (DiDonato, 2013). Applying SSMR in combination with learning domain-specific knowledge moreover positively influences individual students' learning outcomes (Chan, 2012; Saab, van Joolingen, & van Hout-Wolters, 2012).

Although previous studies are positive about the beneficiary impact of SSMR on collaborative learning, it should be noted that the available empirical evidence is limited given that research on SSMR is still in its infancy (Chan, 2012; Khosa & Volet, 2014; Molenaar & Järvelä, 2014; Vauras & Volet, 2013). The challenges for future research are consequently many and diverse, ranging from unambiguously conceptualising SSMR and operationalising the latter in a fine-grained analytical framework allowing assessment of the dynamic interplay between students' individual and socially shared regulation, to conducting output-related studies on the impact of SSMR on both individual students' and the collaborative learning group's outcomes (Grau & Whitebread, 2012; Khosa & Volet, 2014; Perry & Winne, 2013; Volet et al., 2009a). Nevertheless, the current literature is clear on putting forward an urgent call for in-depth analysis of micro-level interactions among collaborative learners aimed at unravelling the sequential and temporal dynamics of SSMR (Chan, 2012; Molenaar & Järvelä, 2014; Vauras & Volet, 2013). Despite growing consensus that SSMR is to be interpreted as a series of events that unfold over time, little is known about how or when SSMR is elicited during collaborative learning, neither about how collaborative learners' socially shared regulation focus evolves over time (Molenaar & Järvelä, 2014). The present study aims at advancing our understanding in this respect by unravelling the temporal characteristics of SSMR and by examining which particular regulation skills or approaches are related to students' socially shared regulation focus.

Peer tutoring

The present study investigates the metacognitive regulation behaviour (including the adoption of SSMR) of collaborative learners participating in a higher education reciprocal peer tutoring intervention. Peer tutoring (PT) is characterised by active academic helping and supporting between peers in small groups or pairs (Falchikov, 2001; Topping, 2005). One peer, the tutor, takes a direct pedagogical responsibility by creating learning opportunities in the PT-group through questioning, clarifying, and active scaffolding (Duran & Monereo, 2005; Roscoe & Chi, 2008). The students being cognitively challenged by this peer tutor, are called tutees. Reciprocal peer tutoring (RPT), in particular, is characterised by the structured exchange of the tutor role in the PT-group (Duran & Monereo, 2005) and enables each student to experience the benefits of providing/receiving academic guidance (Falchikov, 2001; Topping, 2005).

Peer tutors' support generally evolves over time, resulting in a gradual transition from directive tutor-centred to facilitative tutee-centred collaborative learning and regulation (De Smet, Van Keer, & Valcke, 2009; Rasku-Puttonen, Eteläpelto, Arvaja, & Häkkinen, 2003). Initially, the peer tutor acts as a model, initiating tutees' learning, controlling the PT-groups' cognitive discussions, and demonstrating regulation of learning (De Smet et al., 2009; Pata, Sarapuu, & Lehtinen, 2005). As tutees develop more competence, the peer tutor becomes a coach, who indirectly prompts learning and guides knowledge construction, while tutees start to initiate the PT-group's discussions and regulation becomes a joint responsibility of tutor and tutees (De Smet et al., 2009; Rasku-Puttonen et al., 2003). Ultimately, the peer tutor's support fades out as he takes the role of consultant (De Smet et al., 2009). At this stage, the peer tutor merely fine-tunes the PT-groups' collaborative learning, since tutees have taken full ownership of their own and each other's learning. Although the evolution from modelling to consulting tutor support should not be seen as an evolution from tutor-prompted co-regulation to SSMR, it could be assumed that the evolving dynamics between tutor and tutees do create a platform for tutees to progressively participate in the PT-group's metacognitive regulation, either prompting or sharing regulative acts.

Given that direct observation and subsequent internalisation of explicitly modelled regulation behaviour, as well as practicing with and reflecting on regulation, fosters and fine-tunes students' adoption of complex regulation processes (presumably also SSMR) (Hadwin et al., 2005; Hurme et al., 2006; Schraw, Crippen, & Hartley, 2006; Schunk & Zimmerman, 2007; Volet et al., 2009a), RPT is assumed to be a fruitful environment for eliciting and optimising collaborative learners' regulative acts at the social level. RPT's small-scale setting not only allows for intensive metacognitive modelling by a more knowledgeable tutor (De Backer, Van Keer, Moerkerke, & Valcke, in press a; De Smet et al., 2009; King, 1998), its rotating system of assigning the tutor role among collaborative learners might also prevent peer tutors from becoming too directive in regulating the group's learning. By requiring students to alternate between the tutor and tutee role, RPT-participants might attribute equal social status to both roles (Falchikov, 2001; Robinson, Schofield, & Steers-Wentzell, 2005), which might facilitate tutees initiating and sharing RPT-groups' metacognitive regulation. In contrast, fixed PT-formats with cross-age peer tutors (i.e. in which older tutors support younger tutees and tutors' and tutees' role taking remains fixed throughout the PT-intervention, Topping, 2005) might create status differences between tutors and tutees more easily, eliciting tutees' perception of the tutor being responsible for regulating collaborative learning and reinforcing tutor-directed regulative acts (Robinson et al., 2005; Roscoe, 2014). Directive group members are, however, rather hampering for collaborative learners' adoption of SSMR (Rogat & Linnenbrink-Garcia, 2011). Therefore, the present study aims at investigating the potential of RPT for eliciting students' engagement in SSMR, assuming RPT is more facilitative for evoking SSMR. Although the changing dynamics between tutor and tutees during RPT appear to provide collaborative learners a platform for adopting different regulative foci (i.e. individually-oriented, co-regulated by either the tutor or a tutee, or socially shared), to our knowledge, empirical evidence regarding (evolutions in) RPT-groups' metacognitive regulation focus is lacking.

Research questions

SSMR promotes successful collaborative learning (Iiskala et al., 2011; Järvelä et al., 2013; Volet et al., 2009a). Nevertheless, students need time to develop and learn to adopt their SSMR skills (Perry & Winne, 2013; Volet et al., 2009b). Given that interactive instructional tools or learning environments facilitate SSMR (Lajoie & Lu, 2012; Saab et al., 2012), the present study investigates SSMR during RPT. Collaborative learning during RPT spontaneously invites students to apply metacognitive regulation at diverse levels of social interaction (De Backer, Van Keer, & Valcke, 2015). Despite peer tutors' initial modelling and co-regulating, the transition from modelling to coaching peer tutors' support is assumed to create space for tutees to increasingly participate in regulating the collaborative learning process, focussed on either their individual learning, co-regulating other tutees' learning, or socially sharing regulation. The present study aims to unfold time-bound evolutions in RPT-groups' engagement in SSMR, in relation to their adoption of other regulative foci. Additionally, it aims at identifying which particular regulation behaviour stimulates or rather hampers the adoption of a socially shared regulation focus. The following research questions drive the study:

RQ1: How does RPT-groups' adoption of individually-oriented metacognitive regulation, tutor-prompted co-regulation, tutee-prompted co-regulation, and SSMR evolve over time?

RQ2: Is RPT-groups' socially shared regulation focus related to their engagement in particular regulation skills (i.e. orienting, planning, monitoring, and evaluating)?

RQ3: Is RPT-groups' socially shared regulation focus related to their low-/deep-level approach to regulation?

Given that tutors take a direct pedagogical responsibility (McLuckie & Topping, 2004), they are expected to model metacognitive regulation and co-regulate tutees' learning, more specifically during the first RPT-sessions, when tutees' expertise is still limited (De Smet et al., 2009; Hadwin et al., 2005). Tutees are, however, expected to increasingly demonstrate initiative for metacognitive regulation, as they become more familiar with and experienced in RPT, for observation of modelled behaviour ideally results in internalisation and gradually in regulative practice (Hadwin et al., 2005; Schraw et al., 2006; Schunk & Zimmerman, 2007). We therefore hypothesise a decrease in tutor-prompted co-regulation (i.e. co-regulation initiated by the tutor) as the RPT-intervention progresses (hypothesis 1a) and a simultaneous increase in individually-oriented metacognitive regulation (i.e. by tutees being stimulated to regulate their personal learning after observing the tutor as regulative model) (hypothesis 1b), as well as a positive evolution towards enhanced tutee-prompted co-regulation (i.e. co-regulation initiated by the tutee) (hypothesis 1c). Since interactive learning can foster collaborative learners' adoption of SSMR (De Backer et al., 2015; Lajoie & Lu, 2012; Volet et al., 2009a), we furthermore hypothesise that tutees' increased participation in regulating RPT-groups' learning will additionally result in a positive evolution towards enhanced SSMR (hypothesis 1d).

Regarding the second research question, we expect that collective problem solving can encourage students to apply all key regulation skills at the social level. Nevertheless, since RPT-participants mainly engage in monitoring, when discussing and reflecting upon their understanding in order to co-construct knowledge (De Backer et al., in press a; Roscoe, 2014), we hypothesise that especially monitoring will correlate with a socially shared regulation focus (hypothesis 2). On the other hand, orientation, planning, and evaluation are not only less frequently demonstrated during RPT, they are mainly tutor-directed as well (De Backer et al., in press a). Applying these regulation skills might therefore evoke a socially shared regulation focus less easily.

Last, we expect that a deep-level regulation approach will elicit metacognitive conflicts more easily, stimulating reflection and providing input to discuss learning and regulation (Chin & Brown, 2000; Volet et al., 2009b). Since metacognitively-oriented discussions can facilitate SSMR (De Backer et al., 2015; Molenaar et al., 2014), we hypothesise that especially a deep-level regulation approach will correlate with RPT-participants' socially shared regulation focus (hypothesis 3).

Method

Participants and setting

The study was conducted in a naturalistic university setting. Sixty-four first-year Educational Sciences students who already obtained a Professional Bachelor degree (12.5% males and 87.5% females) were randomly assigned to eleven RPT-groups. The RPT-programme was a formal component of the 5-credit course "Instructional Sciences".

RPT-intervention

The RPT-intervention consisted of eight two-hour face-to-face sessions (training session included), in which students tutored each other in fixed groups of six[3]. The tutor role was interchanged at each session within each RPT-group, implying that all students acted as tutor at least once, whereas some students (i.e. those who were appointed as tutor during the first two weeks of the intervention) tutored their peers twice. The tutor role was randomly assigned to students by a university staff member. During each RPT-session, the tutor was primarily responsible for managing the interactions and stimulating collaborative learning, whereas tutees were occupied with solving the group assignment. As a manipulation check, all RPT-groups were observed weekly, to control whether tutors and tutees enacted their roles adequately.

Given that the RPT-intervention was organised for a complete semester, peer tutors' support was expected to evolve from modelling (i.e. during the first RPT-sessions, when students are not yet experienced, neither familiar with the RPT-setting and each other) to coaching (i.e. halfway through the RPT-intervention, when RPT-groups develop routines for tackling the group assignments and peer tutors start to fine-tune managing the collaborative learning process, based on their observation of previous tutors' practices) as the RPT-intervention progressed (De Backer et al., in press a; De Smet et al., 2009). Peer tutors' enhanced expertise was expected to partly come naturally, by gaining more experience during each RPT-session, either practising (in the role of tutor) or observing (in the role of tutee) how to coordinate and regulate collective problem solving. Additionally, by providing ongoing support through supervision (organised halfway through the RPT-intervention) and group-specific feedback sessions (organised every two weeks), students' reflections on their enactment of the tutor and tutee role were stimulated, aimed at optimising their role taking in future RPT-sessions and at encouraging the evolution from modelling to coaching tutor support.

[3] Since 64 students participated in the RPT-intervention, they were randomly divided over nine groups of six students and two groups of five students. The data for this particular study was collected from RPT-groups of six students.

Assignments

During each session, students worked on authentic group assignments, linked to themes in the course "Instructional Sciences" (see De Backer, Van Keer, & Valcke, 2012). The assignments were presented as open-ended tasks requiring students' collaboration and high levels of cognitive processing (Chi et al., 2001). Each assignment consisted of an outline of learning objectives; a subtask to get familiar with the theme-specific terminology; and a subtask to apply theory to real-life cases.

Training

All students participated in a compulsory preliminary tutor training (taking 4.5 hours), one week before the onset of the RPT-intervention. During this training, students were informed about the multidimensional responsibilities of the tutor and were taught a mix of generic tutoring skills. The focus was on establishing a safe learning climate (Falchikov, 2001), managing and stimulating peer interaction (Chi et al., 2001; Webb, Kersting, & Nemer, 2006), asking questions (King, 1998), giving constructive feedback (Webb et al., 2006), and providing scaffolds (Chi et al., 2001). An interactive tutor training was set up, making use of videotaped examples of good and bad practices which were discussed in-depth, role plays in which students experienced multiple tutor responsibilities and received feedback on their tutoring approach, and the in-depth analysis of authentic case studies focusing on specific tutor competences. The outlines of the tutor training were summarised in a manual provided to all students.

Tutor guide

To prepare themselves, peer tutors received a session-specific "tutor-guide" one week in advance. This offered additional information about the theory to focus upon in the RPT-session, for the PT-literature stresses the necessity of a difference in tutors' and tutees' mastery of domain-specific knowledge (Falchikov, 2001; Topping, 2005). After each RPT-session, the tutors for the following RPT-session were given their respective tutor guide. Although the theoretical content of the tutor guide differed across sessions, its structure and design were identical throughout the RPT-intervention. In addition to offering theoretical knowledge, the tutor guide inspired students to approach the problem solving process stepwise, by offering them examples of how to explore task demands, develop actions plans, check whether task requirements are met, and reflect on the outcomes of tutoring. These problem solving steps were depicted in a schematic overview, provided to each tutor.

Interim support

To provide support to tutors (Falchikov, 2001), both a supervision session (taking two hours) and two-weekly feedback sessions (each taking 30 minutes) were organised. The supervision session was set up in small groups of twelve students (recruited from two RPT-groups) and directed by a staff member, who encouraged students to reflect on their behaviour as tutor and tutee. Additionally, the staff member provided group-specific feedback every two weeks, focusing on group dynamics, peer collaboration, equal contribution of tutees, and students' tutoring approach. The feedback resulted in group reflections and action plans to optimise peer collaboration.

Data collection

All RPT-sessions of five randomly selected RPT-groups (i.e. group 2, 3, 5, 8, and 10) were videotaped (i.e. 70h of video recordings, drawn from 30 RPT-participants). The recordings document students' interaction at the onset, throughout, and on completion of the RPT-programme, and allow studying evolutions over time. The video data were recorded in authentic PT-settings and included real-time information about tutors' and tutees' metacognitive interaction.

Coding instrument

First, to identify utterances of metacognitive regulation in the RPT-groups, a coding instrument was developed based on literature about metacognitive regulation (e.g. Meijer et al., 2006; Veenman et al., 1997) and tutoring/peer interactions (e.g. King, 1998; Roscoe & Chi, 2008; Webb et al., 2006). The instrument represents a multi-layered model of metacognitive regulation in collaborative settings. Orienting, planning, monitoring, and evaluating are adopted as the main coding categories and specified with sub-coding categories (i.e. task analysis, activation of prior knowledge, planning in advance, interim planning, comprehension monitoring, monitoring of progress, monitoring of collaboration, evaluation of learning outcomes, evaluation of learning process, evaluation of collaboration). Additionally building on the above literature, a dimension about the approach to metacognitive regulation is included, explicitly identifying the low-/deep-level nature of regulation strategies (De Backer et al., in press b).

Second, to capture the focus of RPT-groups' metacognitive utterances, individually-oriented metacognitive regulation, co-regulation, and SSMR are distinguished as coding categories, based on the regulative agents involved and the reciprocity of the regulative actions. Individually-oriented metacognitive regulation is conceptualised as regulative actions at the individual level, directed at regulation of an individual student's personal learning (Hadwin et al., 2011; Järvelä et al., 2013). Co-regulation is situated at the dyadic or group level and is conceptualised as direct instructions to engage in metacognitive regulation from one peer towards another peer or the RPT-group, respectively (Grau & Whitebread, 2012; Rogat & Adams-Wiggins, 2014; Volet et al., 2009a). Given the PT-context, we distinguish tutor-prompted co-regulation (initiated by the peer tutor) and tutee-prompted co-regulation (initiated by a tutee). SSMR encompasses interdependent regulative actions at the group level (Iiskala et al., 2011; Volet et al., 2013), demonstrated by a joint and reciprocal involvement of multiple (i.e. at least three) students in a particular regulation skill or strategy.

Coding strategy

The coding procedure followed subsequent phases and was exclusively focussed on students' explicitly verbalised interaction. First, each RPT-session was segmented into 'episodes' according to changes in the topic of discussion (Chi et al., 2001). An episode is conceptualised as a brief segment (including multiple conversational turns) of the overall interaction, centred around one particular topic or action. After segmentation, each unit was coded, indicating whether it concerned a metacognitive, task-executive, or off-task episode.

Second, metacognitive episodes were reanalysed for more detailed 'statement coding' (Roscoe & Chi, 2008). A statement represents a single conversational turn since it refers to a single thematically consistent verbalisation of a single metacognitive action by a single student. All metacognitive statements were coded with the developed coding instrument. Its multi-layered structure was reflected in the coded statements: every turn received a general code (indicating the regulation skill it addressed) and a more differentiated code (referring to the concretised regulation strategies). Additionally, the low/deep-level approach in each metacognitive statement was coded.

Third, all metacognitive statements were reanalysed to check the regulative agents involved, their underlying intentions, and the reciprocity of reactions following the statement, in order to identify the focus of RPT-groups' metacognitive regulation (see Appendix A). Conversational segments representing one or more metacognitive statements of a single student, aimed at regulating his personal learning, were labelled as a unit of individually-oriented metacognitive regulation. When a students' metacognitive statement was intended to instruct one or more peers to start regulating, the conversational fragment was labelled as co-regulation. When no metacognitive reaction was given to the initial instruction to regulate, the co-regulation unit merely consisted of the initiating peer's metacognitive statement. In contrast, instructive statements which were followed by a metacognitive reaction from another peer (i.e. action-reaction exchanges at the dyadic level), represented interactive co-regulation units.

The coding of RPT-participants' SSMR focussed on the metacognitive actions of students in reaction to previously demonstrated metacognitive regulation. SSMR-units therefore represented sequences of reciprocal conversational turns (i.e. a sequence of mutual action-reaction exchanges among three or more RPT-participants, referring to one central regulative strategy) (Roscoe & Chi, 2008). In a SSMR-unit, multiple students jointly regulate towards a common goal, implying the regulation process proceeds through different (i.e. at least three) RPT-participants' metacognitive statements. The start of an interactive SSMR-unit consisted of a RPT-participant's metacognitive statement forming the trigger for other students to join in the initiated regulative action, whereas the end of the unit was marked by the last metacognitive statement directed at mutual engagement in metacognitive regulation. Both the start and end of an interactive SSMR-unit could be traced back when all students' reciprocal statements reflect a socially shared metacognitive focus (Iiskala et al., 2011).

The coding of the video data was accomplished by two independent trained coders. They double-coded 25% of the recorded sessions (5924 statements) to determine interrater reliability. Cohen's

Kappa indicates high interrater reliability for the coding of metacognitive regulation (κ = .89) and good agreement beyond chance for the coded regulative foci (κ = .82).

Data analysis

After coding, the frequency of occurrence of metacognitive regulation skills and adopted foci during metacognitive regulation was calculated for each group and session. In total, 14968 metacognitive statements were identified, 7661 units represented the RPT-groups' regulation focus during metacognitive regulation. Regarding the first research question, a two-step analysis procedure was followed: data from the seven RPT-sessions were initially regrouped in three phases, to unravel evolutions in RPT-groups' metacognitive regulation from the starting (sessions 1-2) over the intermediate (sessions 3-4) to the closing (sessions 5-7) phase. Using mixed models for logistic regression analysis, the odds of the different regulation foci (i.e. individually-oriented metacognitive regulation, tutor- and tutee-prompted co-regulation, and SSMR) are modelled as a function of phase. In a second step, for regulation foci reflecting significant changes in occurrence over time, mixed models for logistic regression with change points were used to investigate at which RPT-session a change in evolution rate occurs (Pastor & Guallar, 1998). We tested six models: a model without change points and models with change points at each measuring occasion. The best fitting model is selected based on its AIC (i.e. Akaike Information Criterion). We also consider confidence intervals for the odds ratios and calculate the logit d effect size (Kline, 2004), to express an odds ratio on a scale comparable to effect sizes for continuous outcomes, such as Cohen's d.

To study the relationship between RPT-groups' socially shared regulation focus and particular regulation skills on the one hand (RQ2), the approach to regulation on the other hand (RQ3), binary logistic regression analyses were performed. The occurrence (i.e. occurrence versus non-occurrence) of SSMR served as binary dependent variable. In a first model, the occurrence (versus non-occurrence) of orientation, planning, monitoring, and evaluation served as independent binary variables. In a second model, the occurrence (versus non-occurrence) of low-level and deep-level metacognitive regulation served as independent binary variables. In both models, non-occurrence of the abovementioned regulation skills and approaches served as reference category. To analyse the strength of identified significant relations, odds ratios were calculated. The significance level was set at .05 for all analyses.

Results

Descriptives on RPT-groups' metacognitive regulation

Table 1 depicts increasing adoption of metacognitive regulation throughout the three phases, more specifically orientation, evaluation, and monitoring. Whereas problem solving initially starts without much orientation (4.71%), RPT-groups increasingly orient themselves in the closing phase

(11.20%). Similarly, adoption of evaluation grows from the starting (3.70%) to the closing phase (9.32%). Table 1 shows a dominance of monitoring in all phases. Despite an increased adoption of monitoring at the intermediate and closing phase, this evolution is less pronounced compared to the trends in orientation and evaluation. In contrast, planning remains limited and rather stable (see Table 1).

Table 2 reveals a dominance of low-level metacognitive regulation from the starting to the closing phase. Although RPT-groups gradually adopt more deep-level regulation at the intermediate (22.70%) and closing phase (32.29%), this trend cannot be discerned for all regulation skills. RPT-groups' deep-level planning and evaluation remain negligible (see Table 2). In contrast, their involvement in deep-level orientation and monitoring increases from the starting (2.53% and 5.29%, respectively) to the closing phase (10.21% and 19.20%, respectively).

Table 1. *Frequency of occurrence of metacognitive regulation in the RPT-groups during the three phases (frequencies and percentages)*

Metacognitive regulation	**Starting phase**		**Intermediate phase**		**Closing phase**	
	frequency	*%*	*frequency*	*%*	*frequency*	*%*
Orientation	**145**	**4.71**	**402**	**9.74**	**869**	**11.20**
Task analysis	56	1.82	109	2.64	194	2.50
Activating prior knowledge	60	1.95	288	6.98	654	8.43
Awareness of task perceptions	29	0.94	5	0.12	21	0.27
Planning	**227**	**7.37**	**304**	**7.36**	**541**	**6.97**
Planning in advance	13	0.42	17	0.41	22	0.28
Interim planning	214	6.95	287	6.95	519	6.69
Monitoring	**2593**	**84.22**	**3150**	**76.31**	**5626**	**72.49**
Comprehension monitoring	1832	59.50	2274	55.09	3882	50.02
Monitoring of progress	731	23.74	758	18.36	1551	19.98
Monitoring of collaboration	30	0.97	118	2.86	193	2.49
Evaluation	**114**	**3.70**	**272**	**6.59**	**723**	**9.32**
Evaluating learning outcomes	42	1.36	85	2.06	373	4.81
Evaluating learning process	54	1.75	129	3.13	253	3.26
Evaluating collaboration	18	0.59	58	1.40	97	1.25
Total	**3079**	**100**	**4128**	**100**	**7761**	**100**

Table 2. *Frequency of occurrence of low-level and deep-level metacognitive regulation in the RPT-groups during the three phases (frequencies and percentages)*

Regulation approach	**Starting phase**		**Intermediate phase**		**Closing phase**		**Total**	
	frequency	*%*	*frequency*	*%*	*frequency*	*%*	*frequency*	*%*
Low-level	**2757**	**91.69**	**3163**	**77.30**	**5212**	**67.71**	**11132**	**78.90**
Orientation	43	1.43	55	1.35	64	0.83	162	1.20
Planning	217	7.22	291	7.11	477	6.20	985	6.84
Monitoring	2389	79.45	2598	63.49	4108	53.37	9095	65.44
Evaluation	108	3.59	219	5.35	563	7.31	890	5.42
Deep-level	**250**	**8.31**	**929**	**22.70**	**2486**	**32.29**	**3665**	**21.10**
Orientation	76	2.53	344	8.41	786	10.21	1206	7.05
Planning	9	0.29	13	0.32	62	0.80	84	0.47
Monitoring	159	5.29	519	12.68	1478	19.20	2156	12.39
Evaluation	6	0.20	53	1.29	160	2.08	219	1.19

Time-bound evolutions in RPT-groups' adopted regulative foci (RQ1)

Despite a general dominance of tutor-prompted co-regulation (see Table 3), the latter decreases from the starting (53.48%) to the closing phase (37.72%). Table 4 (step 1) moreover reveals significant differences in RPT-groups' tutor-prompted co-regulation. The odds of tutor-prompted co-regulation are 1.48 times lower at the intermediate compared to the starting phase (p<.001) and 0.73 times lower when comparing the closing with the intermediate phase (p<.001). Figure 2a illustrates this time-bound evolution in RPT-groups' decreasing tutor-prompted co-regulation.

Table 3 reveals that RPT-groups' individually-oriented metacognitive regulation remains rather stable from the starting to the intermediate phase, but decreases from the intermediate to the closing phase. Table 4 (step 1) moreover demonstrates significant differences over time: whereas the odds of individually-oriented metacognitive regulation do not change from the starting to the intermediate phase (p=.435), they become 0.68 times lower when comparing the closing with the intermediate phase (p<.001). Figure 2b illustrates this time-bound evolution in RPT-groups' individually-oriented metacognitive regulation.

In contrast, tutee-prompted co-regulation is gradually more frequently adopted as the RPT-intervention progresses (see Table 3). Table 4 (step 1) demonstrates significant differences in RPT-groups' adoption of tutee-prompted co-regulation. Compared to the starting phase, the odds of tutee-prompted co-regulation are 1.05 times higher at the intermediate phase (p<.001). No significant changes are shown, however, when comparing the intermediate with the closing phase (p=.070). Figure 2c depicts RPT-groups' positive evolution towards tutee-prompted co-regulation during the first intervention half.

Table 3. *Frequency of occurrence of the adopted foci of RPT-groups' metacognitive regulation during the three phases (frequencies and percentages)*

	Starting phase		**Intermediate phase**		**Closing phase**		**Total**	
	frequency	*%*	*frequency*	*%*	*frequency*	*%*	*Frequency*	*%*
Focus of MR								
individually-oriented MR	473	26.77	607	27.50	813	22.05	1893	24.71
tutor-prompted co-regulation	945	53.48	956	43.32	1391	37.73	3292	42.97
tutee-prompted co-regulation	313	17.70	580	26.28	1186	32.17	2079	27.14
socially shared MR	36	2.04	64	2.90	297	8.06	397	5.18
Total	**1767**	**100**	**2207**	**100**	**3687**	**100**	**7661**	**100**
SSMR								
SS orientation	0	0	3	0.76	36	9.07	39	9.83
SS planning	0	0	2	0.50	2	0.50	4	1.00
SS monitoring	36	9.07	58	14.61	247	62.21	341	85.89
SS evaluation	0	0	1	0.25	12	3.03	13	3.28
Total	**36**	**9.07**	**64**	**16.12**	**297**	**74.81**	**397**	**100**

Note: SS= socially shared; MR= metacognitive regulation

Although RPT-groups' engagement in SSMR is less prominent compared to their adoption of the other regulative foci, Table 3 reveals an increase in SSMR from the starting (2.04%) to the closing phase (8.06%). Although a socially shared regulation focus is increasingly adopted during orientation and monitoring, planning and evaluation are hardly shared (see Table 3). Table 4 (step 1) confirms significant differences in RPT-groups' adoption of SSMR. Although the odds of SSMR do not change from the starting to the intermediate phase (p=.185), they increase 2.58 times (p<.001) from the intermediate to the closing phase (moderate effect size *logit* d=0.52). In-depth analysis of the change in RPT-groups' adoption of SSMR furthermore reveals a significant change in evolution rate at RPT-session 4 (*factor* 1.28; p=.004). Whereas the odds of SSMR do not change significantly when shifting from one RPT-session to the next during the first intervention half, the odds of SSMR become 1.46 times higher (p<.001) after RPT-session 4 (see Table 4 step 2), implying a considerably larger evolution towards SSMR after this point in time. Figure 2d illustrates this time-bound evolution towards RPT-groups' increased adoption of SSMR.

Similar evolutions are revealed when analysing RPT-groups' socially shared regulation focus when applying particular regulation skills (i.e. orientation and monitoring[4]).Whereas no significant changes could be distinguished from the starting to the intermediate phase for RPT-groups' socially shared focus during orientation and monitoring (see Table 4 step 1), the odds of socially shared orientation and monitoring are respectively 1.98 (p=.002) and 2.23 times (p<.001) higher at the closing compared to the intermediate phase (small effect sizes *logit* d=0.38 and 0.44, respectively). Although RPT-groups evolve towards significantly increased adoption of a socially shared regulation focus when orienting and monitoring (see Figure 3a and Figure 3b), no significant change in evolution rate could be distinguished (see Table 4 step 2).

Comparable results are demonstrated when analysing RPT-groups' socially shared regulation focus, taking into account their low versus deep-level regulation approach. Table 4 (step 1) shows that the odds of a socially shared regulation focus when applying low-level or deep-level regulation do not change significantly at the intermediate compared to the starting phase (p=.667 and p=.171, respectively). In contrast, the odds are 1.64 times higher (p=.004) at the closing compared to the intermediate phase when adopting a low-level regulation approach, and 4.86 times higher (p<.001) when adopting a deep-level regulation approach (large effect size *logit* d=0.87). Figure 4a and Figure 4b illustrate RPT-groups' time-bound evolutions towards enhanced adoption of a socially shared regulation focus when engaging in low-level versus deep-level regulation. Significant changes in evolution rate in both evolution patterns could, however, not be identified (see Table 4 step 2).

[4] Mixed models for logistic regression aimed at unravelling time-bound evolutions in RPT-groups' adoption of a socially shared regulation focus during planning and evaluation, are not conducted, given the limited frequency of occurrence of socially shared planning and evaluation (see Table 3).

Table 4. *Evolutions in the focus of RPT-groups' adopted metacognitive regulation*

	Step 1: Evolutions over intervention phases[1]		**Step 2: Evolutions over 7 RPT-sessions, identifying change points**[2]			
	$e^{\widehat{\beta_1}}$ $[95\%CI]$[3] **logit d (95% CI)**	$e^{\widehat{\beta_2}}$ $[95\%CI]$[4] **logit d (95% CI)**	**Change point**	$e^{\widehat{\gamma_1}}$ $[95\%CI]$[5] **logit d (95% CI)**	$e^{\widehat{\gamma_1}+\widehat{\gamma_2}}$ $[95\%CI]$[6] **logit d (95% CI)**	**Change in evolution rate:** $e^{\widehat{\gamma_2}}$ $[95\%CI]$[7]
Evolutions in the focus of RPT-groups' metacognitive regulation						
Individually-	1.05 [0.92, 1.20]	0.68 [0.61, 0.76]***	Session 3	1.07 [0.98, 1.16]	0.83 [0.80, 0.87]***	0.78 [0.70, 0.87]***
oriented MR	0.03 [-0.04, 0.10]	-0.21 [-0.28,-0.15]		0.04 [-0.01, 0.08]	-0.10 [-0.12,-0.08]	
Tutor-prompted co-	1.48 [1.33, 1.65]***	0.73 [0.66, 0.80]***	Session 3	0.78 [0.74, 0.84]***	0.89 [0.86, 0.92]***	1.13 [1.04,1.24]**
regulation	0.22 [0.16, 0.27]	-0.16 [-0.23,-0.12]		-0.13 [-0.17,-0.10]	-0.06 [-0.08,-0.05]	
Tutee-prompted	0.69 [0.60, 0.80]***	1.10 [0.99, 1.23]	Session 2	1.58 [1.28, 1.93]***	1.06 [1.03, 1.09]***	0.68 [0.54, 0.84]***
co-regulation	-0.20 [-0.28,-0.12]	0.05 [-0.01, 0.11]		0.25 [0.14, 0.37]	0.03 [0.02, 0.05]	
SSMR	0.83 [0.54, 1.28]	2.58 [1.92,4 .86]***	Session 4	1.14 [0.97, 1.35]	1.46 [1.32, 1.61]***	1.28 [1.01, 1.64]**
	0.10 [-0.34,0.14]	0.07 [0.04, 0.09]		0.07 [-0.02, 0.16]	0.21 [0.15, 0.26]	

[1] This column provides information on the change in odds of a particular regulative focus at a single segment when comparing the starting with the intermediate phase and the intermediate with the closing phase, respectively.

[2] This column provides information on the change in odds of a particular regulative focus at a single segment when shifting from one RPT-session to the next RPT-session and indicates whether and at which RPT-session a significant change point (i.e. change in evolution rate) can be identified.

[3] This column presents evolutions from the starting to the intermediate phase. For each regulative focus, the change in odds at a single segment (i.e. factor and corresponding 95% confidence interval on the first row) and effect size of the evolution (i.e. logit d and corresponding 95% confidence interval on the second row) is presented.

[4] This column presents evolutions from the intermediate to the closing phase. For each regulative focus, the change in odds at a single segment (i.e. factor and corresponding 95% confidence interval on the first row) and effect size of the evolution (i.e. logit d and corresponding 95% confidence interval on the second row) is presented.

[5] This column presents evolutions in RPT-groups' regulative foci over the 7 RPT-sessions. For each regulative focus, the change in odds at a single segment from RPT-session 1 to the subsequent RPT-session before the change point session (i.e. factor and corresponding 95% confidence interval on the first row) and effect size of the evolution (i.e. logit d and corresponding 95% confidence interval on the second row) is presented.

[6] This column presents evolutions in RPT-groups' regulative foci over the 7 RPT-sessions. For each regulative focus, the change in odds at a single segment from the change point session to the subsequent session until RPT-session 7 (i.e. factor and corresponding 95% confidence interval on the first row) and effect size of the evolution (i.e. logit d and corresponding 95% confidence interval on the second row) is presented.

[7] This column presents the change in evolution rate before and after the change point (i.e. factor and corresponding 95% confidence interval) for each regulative focus.

Evolutions in RPT-groups' socially shared regulation focus when adopting particular regulation skills						
SS orientation	0.83 [0.53, 1.29]	1.98 [1.46, 2.70]**	Session 3	1.01 [0.76, 1.33]	1.31 [1.48, 2.93]***	1.30 [0.93, 1.82]
	-0.11 [-0.35, 0.14]	0.38 [0.21, 0.55]		0.01 [-0.27, 0.28]	0.15 [0.11, 0.59]	
SS monitoring	0.89 [0.57, 1.40]	2.23 [1.62, 3.06]***	Session 2	0.65 [0.37, 1.14]	1.33 [1.22, 1.45]***	2.05 [1.12, 3.75]
	-0.06 [-0.31, 0.18]	0.44 [0.27, 0.62]		-0.24[-0.55, 0.07]	0.16 [0.11, 0.20]	
SSMR during LL	0.90 [0.56, 1.45]	1.64 [1.16, 2.32]**	Session 2	0.63[0.35, 1.13]	1.25 [1.13, 1.37]***	1.98 [1.04, 3.79]
regulation	-0.06 [-0.32, 0.20]	0.27 [0.08, 0.47]		-0.25[-0.58, 0.07]	0.12 [0.07, 0.17]	
SSMR during DL	0.45[0.15, 1.41]	4.86 [2.67, 8.85]***	Session 2	2.23[0.93, 5.38]	1.60 [0.62, 1.85]***	1.40 [0.54, 3.59]
regulation	-0.44 [-1.06, 0.19]	0.87 [0.54, 1.20]		0.44[-0.04, 0.92]	0.26 [0.16, 0.34]	

Note: MR= metacognitive regulation; SS= socially shared; LL= low-level; DL=deep-level; **p<.05; ***p<.001

Table 5. *Logistic regression estimates for the occurrence of socially shared metacognitive regulation in the RPT-groups*

	Estimate	*SE*	*Wald*	*df*	*p*	*OR*	*95% CI*
Orientation	2.10	0.27	130.28	1	.000	8.17	[0.86, 1.45]
task analysis	1.57	0.73	4.60	1	.032	4.84	[0.08, 1.65]
prior knowledge activation	2.12	0.26	161.13	1	.000	8.33	[0.89, 1.45]
Planning	0.50	0.74	0.46	1	.498	1.65	[-1.52, 1.08]
Monitoring	2.14	0.22	201.58	1	.000	8.49	[0.92, 1.42]
comprehension monitoring	2.18	0.20	280.09	1	.000	8.84	[0.99, 1.42]
monitoring of progress	1.25	0.34	13.67	1	.000	3.49	[0.32, 1.06]
Evaluation	0.89	0.62	2.12	1	.145	2.45	[-0.18, 1.16]
LL regulation	1.81	0.22	157.19	1	.000	6.11	[0.76, 1.24]
LL orientation	0.72	0.74	0.96	1	.327	2.06	[-0.40, 1.20]
LL monitoring	2.00	0.22	177.89	1	.000	7.38	[0.86, 1.34]
DL regulation	2.22	0.23	222.88	1	.000	9.21	[0.98, 1.47]
DL orientation	2.15	0.27	144.18	1	.000	8.58	[0.89, 1.48]
DL monitoring	2.27	0.24	234.91	1	.000	9.67	[0.99, 1.51]

Note: LL= low-level; DL= deep-level; OR= odds ratio; CI= confidence interval

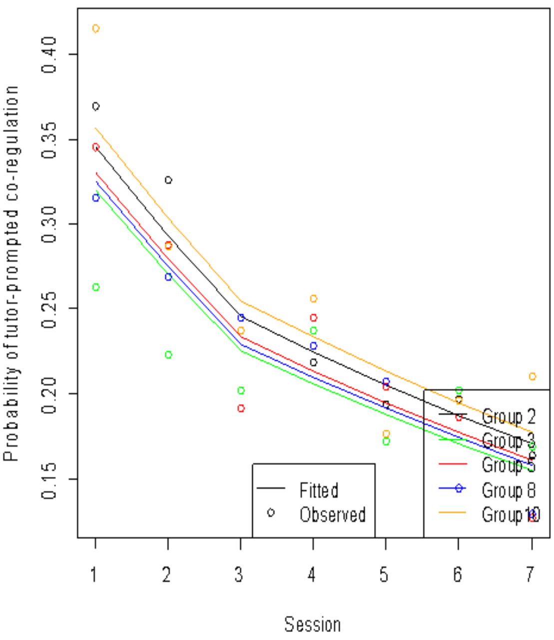

Figure 2a. Evolution in tutor-prompted co-regulation

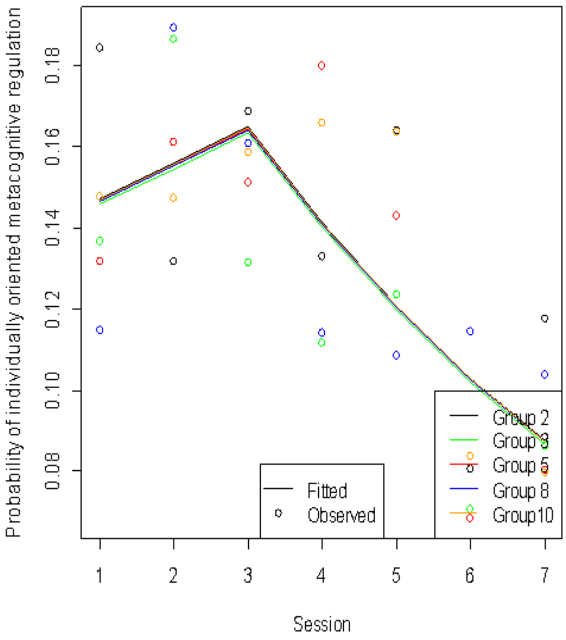

Figure 2b. Evolution in individually-oriented metacognitive regulation

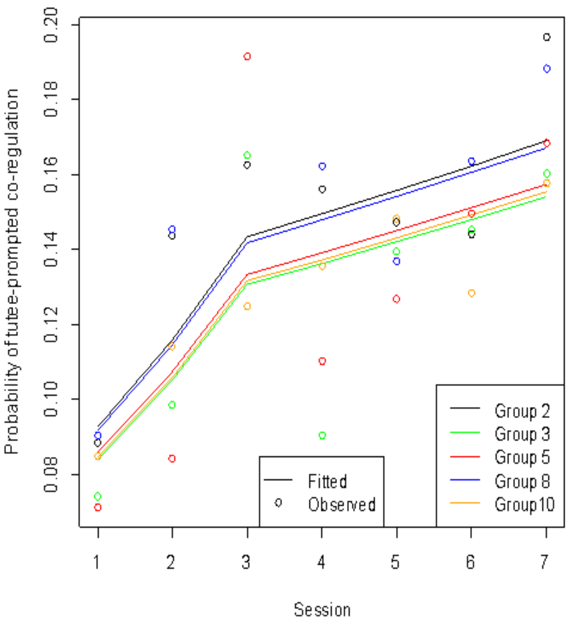

Figure 2c. Evolution in tutee-prompted co-regulation

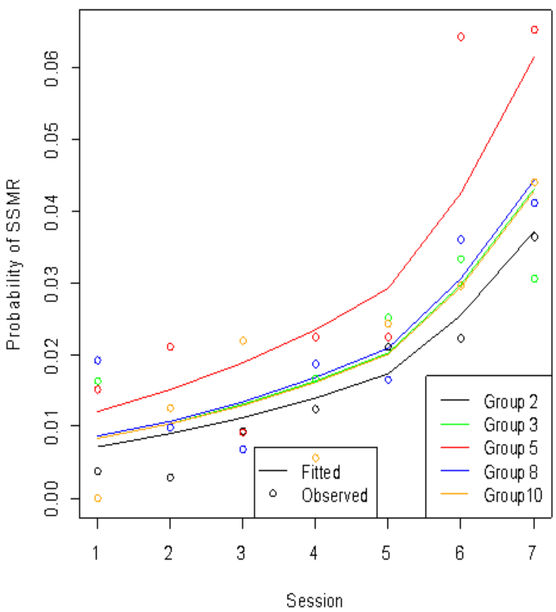

Figure 2d. Evolution in SSMR

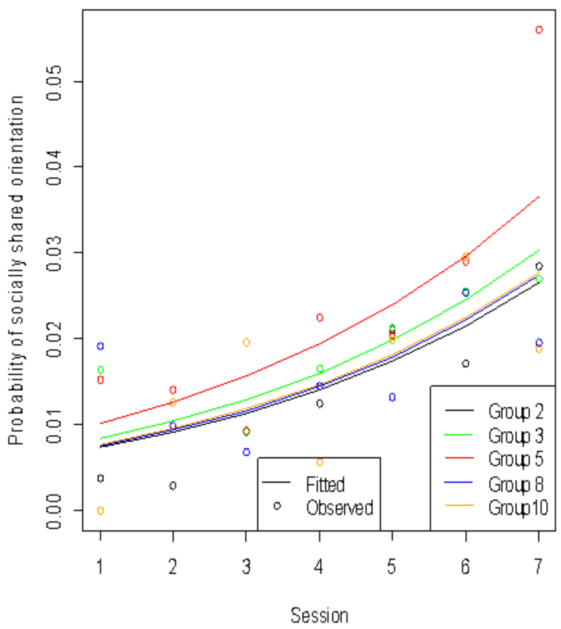

Figure 3a. Evolution in socially shared orientation

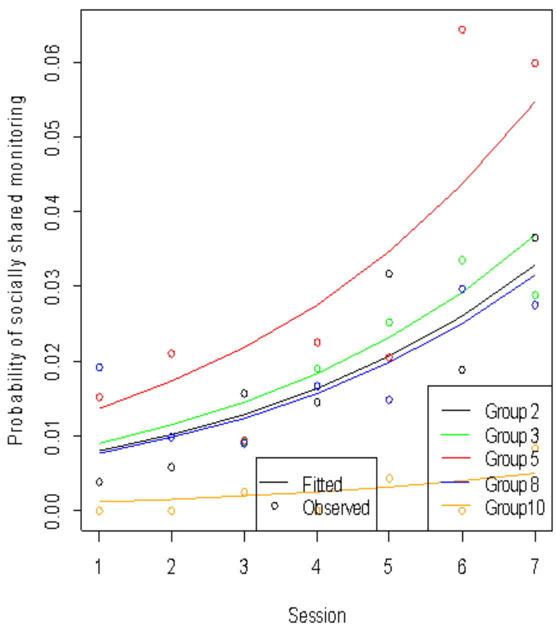

Figure 3b. Evolution in socially shared monitoring

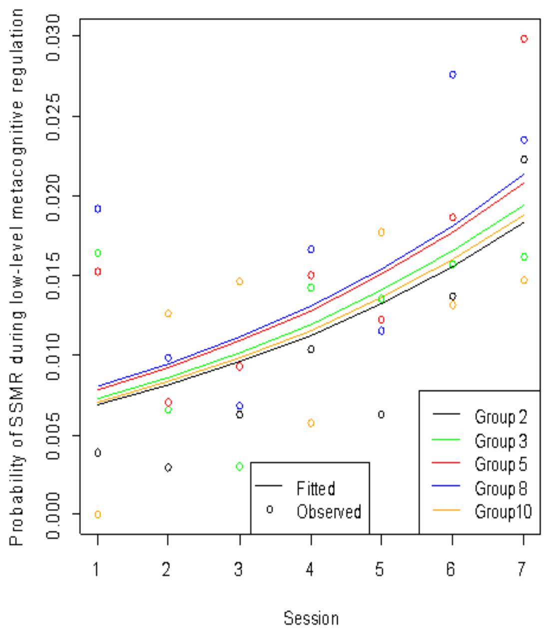

Figure 4a. Evolution in SSMR when adopting low-level metacognitive regulation

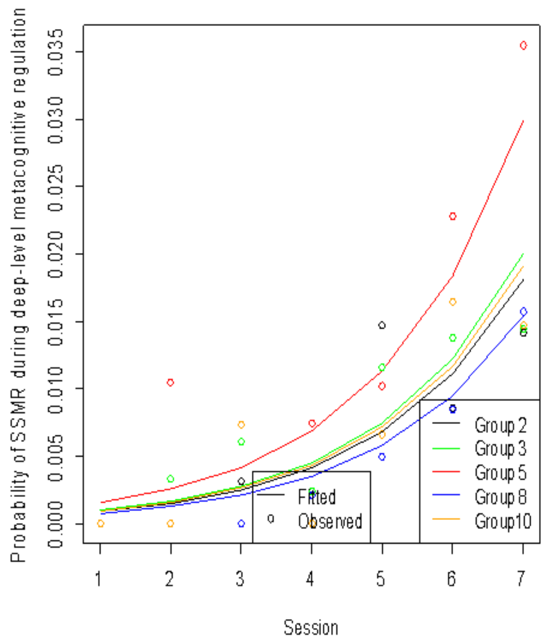

Figure 4b. Evolution of SSMR when adopting DL metacognitive regulation

The relationship between RPT-groups' socially shared regulation focus and their adoption of particular regulation skills (RQ2)

The second research question aims at examining whether there are particular regulation skills which significantly increase the probability of adopting a socially shared regulation focus. Binary logistic regression analysis reveals a significant association between RPT-groups' socially shared regulation focus and their engagement in particular regulation skills ($\chi^2(4)=286.38$; $p<.001$). Table 5 more specifically demonstrates that planning and evaluation are not significantly correlated with SSMR ($p=.498$ and $p=.145$, respectively), whereas orientation and monitoring show a significant positive association (both $p<.001$). Based on the odds ratio, a socially shared regulation focus is 8.17 times more likely to be demonstrated during orientation and 8.49 times more during monitoring. Although all orientation and monitoring strategies increase the probability of adopting a socially shared regulation focus, the strongest correlations are revealed for RPT-groups' activation of prior knowledge and comprehension monitoring. The odds of a socially shared regulation focus are, more specifically, 8.33 times higher during prior knowledge activation, whereas they are 8.84 times higher in episodes of comprehension monitoring.

The relationship between RPT-groups' socially shared regulation focus and their adoption of low- versus deep-level regulation (RQ3)

RPT-groups' socially shared regulation focus is significantly correlated with their adoption of a low- or deep-level regulation approach ($\chi^2(2)=252.53$; $p<.001$). The odds of a socially shared regulation focus are respectively 6.11 and 9.21 times higher when RPT-groups apply low-level versus deep-level metacognitive regulation. It should be noted, however, that the significant association between SSMR and a low-level regulation approach is, only revealed for monitoring (see Table 5). The odds of a socially shared regulation focus are 3.52 times higher during low-level comprehension monitoring and 2.20 times higher during low-level monitoring of progress, but are not significantly related to RPT-groups' adoption of low-level orientation ($p=.327$). In contrast, both deep-level orientation and monitoring significantly increase the probability of SSMR (both $p<.001$). More specifically, deep-level prior knowledge activation and comprehension monitoring demonstrate a strong correlation with adopting a socially shared regulation focus, increasing the odds of the latter 8.33 times and 8.84 times, respectively. On the other hand, the odds of adopting a socially shared regulation focus become 3.00 times higher during deep-level task analysis and 3.60 times higher during deep-level monitoring of progress.

Discussion

The present study provided an in-depth analysis of micro-level interactions among RPT-participants aimed at unravelling time-bound evolutions in RPT-groups' adoption of SSMR and at identifying which particular regulation behaviour (i.e. regulation skills and approaches) is correlated with RPT-groups' adoption of a socially shared regulation focus. Its innovative perspective on SSMR as a series of events that unfold over time during particular learning and regulation activities, contributes directly to the emergent research on SSMR. Whereas previous studies mainly focussed on conceptualising and empirically validating social forms of regulation, the present study extends this prior work by unravelling both the temporal dynamics of SSMR and the conditions facilitating the adoption of SSMR, advancing both educational research and practice.

Time-bound evolutions in RPT-groups' regulative foci

The results of the present study revealed significant positive time-bound evolutions towards enhanced adoption of tutee-prompted co-regulation and SSMR, as well as significant negative evolutions in RPT-groups' tutor-prompted co-regulation and individually-oriented metacognitive regulation. In line with our hypothesis, tutors appeared to operate mainly as metacognitive models at the start of the RPT-intervention, as demonstrated in RPT-groups' initial dominant involvement in tutor-prompted co-regulation. Nevertheless, as was equally hypothesised, tutees appeared to progressively participate in regulating RPT-groups' learning as they gained more experience and expertise in the RPT-setting, while tutors seemed to take a less directive role towards individual tutees' and the group's regulation. These trends are reflected in the significant decrease in tutor-prompted co-regulation and significant increase in tutee-prompted co-regulation as the RPT-sessions progressed. Although it seems plausible that the evolution from modelling to coaching tutor support is up to some extent related to an evolution from tutor-prompted co-regulation to tutee-prompted co-regulation (Hadwin et al., 2005; Rogat & Adams-Wiggins, 2014), it should be acknowledged that the increase in tutee-prompted co-regulation might also be explained by socio-emotional variables, such as tutees' enhanced acquaintanceship with the RPT-setting and the members of their RPT-group, which might have promoted their confidence in or motivation for participating in the RPT-sessions, including starting to co-regulate other tutees' or the group's regulation more frequently (Rogat & Linnenbrink-Garcia, 2011; Volet et al., 2009b; Webb et al., 2006). Future research examining tutors' and tutees' co-regulative acts in combination with the evolving support of peer tutors is needed to grasp a better understanding of RPT-groups' evolution towards increased tutee-prompted co-regulation.

In contrast to our expectation, RPT-groups' evolution towards decreasing tutor-promoted co-regulation did not imply a positive evolution in individually-oriented metacognitive regulation, given that the latter did not change significantly during the first intervention half and even decreased during the second intervention half. This result supports recent claims that co-regulation should not necessarily be conceptualised as a transitional phase towards self-regulation, but can be interpreted as a specific type of metacognitive regulation along the social spectrum as well (Rogat & Adams-Wiggins, 2014; Volet et al., 2013). Observation of modelled regulation behaviour by the peer tutor (i.e. during tutor-prompted co-regulation) might have stimulated tutees to apply and refine their metacognitive regulation skills (Hadwin et al., 2005; Schraw et al., 2006). Nevertheless, the present results suggest that the social and interactive nature of RPT encouraged tutees more easily to direct their enhanced regulative practice towards collaborating peers' learning (i.e. as demonstrated in RPT-groups' positively evolving tutee-prompted co-regulation) instead of stimulating tutees to optimise their personal learning through individually-oriented regulative acts. It should be noted, however, that tutees' prompts to instruct other peers into metacognitive regulation are generally explicitly verbalised and can therefore be identified more easily (Iiskala et al., 2011; Volet et al., 2013). On the other hand, it seems plausible that students' individually-oriented regulative acts might have sometimes remained covert, making it difficult to assess them appropriately (Grau & Whitebread, 2012; Vauras & Volet, 2013). Future research applying data triangulation (e.g. additional coding of RPT-participants' non-verbal regulation behaviour, stimulated recall interviews with tutors and tutees allowing them to express their regulative thoughts and acts, or making use of trace data of RPT-participants' collaboration in online learning environments) could help to optimally portray RPT-groups' evolving adoption of individually-oriented metacognitive regulation (Molenaar & Järvelä, 2014; Perry & Winne, 2013; Volet et al., 2013).

The results of the present study further confirm the hypothesis that RPT-groups' metacognitive regulation becomes increasingly socially shared as students become more familiar with the RPT-setting and each other. Although their involvement in SSMR was not as pronounced as their adoption of co-regulation or individually-oriented metacognitive regulation, a significant positive time-bound evolution towards increased SSMR was shown as the RPT-intervention progressed. In line with previous research, the current findings demonstrated, nevertheless, that RPT-participants needed time and regulative practice to develop or optimise the skills required for sharing and reciprocally contributing to regulating the RPT-group's learning, given that RPT-groups' adoption of SSMR only significantly increased after the fourth RPT-session, halfway through the RPT-intervention (Molenaar & Järvelä, 2014; Perry & Winne, 2013; Volet et al., 2009b). This finding implies that educators should preferably design middle-long to long-term collaborative learning programmes (e.g. RPT) in order to provide students the time they need to learn to appropriately adopt a socially shared regulation focus.

Since identifying positive or negative correlations between characteristics of RPT-groups' collaborative learning and their adoption of SSMR was not in the scope of the present study, it is rather difficult to clarify RPT-groups' evolutions towards enhanced SSMR based on the current findings. Our results do suggest nevertheless that the dynamics between tutors and tutees, more specifically the changes in peer tutors' support as students become more skilled in RPT, play an essential role in eliciting RPT-participants' engagement in SSMR. Initially, RPT-groups' metacognitive regulation was characterised by a dominance of tutor-prompted co-regulation, probably related to peer tutors operating as metacognitive models, demonstrating particular regulation behaviour and instructing tutees to act likewise (De Smet et al., 2009; Rasku-Putonen et al., 2003). In comparison, both RPT-groups' tutee-prompted co-regulation and SSMR appeared to be limited in this initial phase. This finding suggests that the instructive nature of peer tutors' modelling support leaves limited space for tutees' regulative contributions and confirms previous findings that directive group members are rather hampering for collaborative learners' involvement in SSMR (Rogat & Linnenbrink-Garcia, 2011). As tutees gained more competence in the RPT-setting, they started to participate significantly more frequently in prompting other tutees' regulation as well as in sharing regulative acts at the interpersonal level (whereas a simultaneous decline was revealed for tutor-prompted co-regulation, probably connected to tutors' coaching support). Although the evolution from modelling to coaching should not be equated with an evolution from tutor-prompted co-regulation to SSMR, the evolving dynamics between tutors and tutees do appear to create a platform for tutees to start engaging in social forms of metacognitive regulation. The finding that tutee-prompted co-regulation significantly increased (during the first RPT-intervention half) prior to a significant enhancement of RPT-groups' SSMR (during the second intervention half), moreover suggests that tutees' initiative for metacognitive regulation might be essential for RPT-groups to adopt a socially shared regulation focus. Future research is needed to investigate whether the evolution towards increased SSMR, unfolded in the present study, is merely time-bound and can consequently be identified in other collaborative learning contexts as well, or whether the adoption of SSMR is rather facilitated by the inherent dynamics of (R)PT-settings.

In addition to time-related factors, the possible influence of students' perceptions of the tutor versus tutee role and corresponding responsibilities on RPT-groups' evolving adoption of SSMR should be acknowledged as well (Robinson et al., 2005; Roscoe, 2014). It seems plausible that tutees perceived the tutor as being primarily responsible for managing and regulating the group's learning during the starting phase, which might have limited their initiative for prompting or sharing the group's metacognitive regulation (De Smet et al., 2009; Roscoe, 2014). Similarly, their growing competence in RPT at the intermediate and closing intervention phase might have modified this initial perception, leading tutees to acknowledge that they share a responsibility for regulating collaborative learning with the tutor. This might in its turn have promoted their regulative contributions as well as the group's involvement in SSMR (Rogat & Adams-Wiggins, 2014). Future research by means of stimulated recall interviews with RPT-participants could detect students' perceptions on tutor versus tutee responsibilities and unravel the interplay between these perceptions and the evolutions in RPT-groups' adopted regulative foci.

The relation between RPT-groups' regulation skills and approaches and their adoption of a socially shared regulation focus

In line with our hypotheses, not all of RPT-groups' metacognitive regulation behaviour appeared to be equally important for the adoption of a socially shared regulative focus. Orienting and monitoring significantly increased the probability of shared regulative acts, whereas planning and evaluating were not significantly associated with RPT-groups' socially shared regulation focus. Additionally, a deep-level regulation approach appeared to encourage RPT-groups more easily into SSMR, as compared to low-level regulation. Although it seems plausible that regulation behaviour which is frequently demonstrated is more likely to engage students in interactive peer discussions, which might in its turn enhance the probability of starting to share the regulation activity (Molenaar & Järvelä, 2014; Rogat & Linnenbrink-Garcia, 2011), the current findings suggest that especially the nature of particular regulation behaviour influences RPT-groups' socially shared regulation focus. Since deep-level comprehension monitoring and activation of prior knowledge showed the strongest correlations with applying a socially shared regulation focus, the present study more specifically highlights the importance of profoundly processing and co-constructing knowledge, eliciting students' critical reflections on their understanding. Conceptual peer discussions and joint problem solving presumably invited students to clarify and question one's own and each other's understanding (during monitoring) and prior knowledge (during orientation), invoking socio-cognitive conflicts and metacognitive control of learning when differences in peers' reasoning were exposed (Hurme et al., 2006; King, 1998). Solving these conflicts probably demanded for mutual negotiation of peers' initially contrasting understanding, which might have facilitated students' shared metacognitive engagement at the interpersonal level when orienting and monitoring (Iiskala et al., 2011; Volet et al., 2009b). The fact that particularly higher-order learning, aimed at elaboration and justification of students' understanding, encourages collaborative learners into reflective and reciprocal peer discussions (Iiskala et al., 2011; King, 1998; Roscoe & Chi, 2008) and that deep-level regulation is more likely to be adopted during such higher-order learning (De Backer et al., 2015; Rogat & Linnenbrink-Garcia, 2011; Volet et al., 2009a), might moreover explain the current finding that especially RPT-groups' involvement in deep-level regulation was strongly associated with their socially shared regulation focus.

In contrast to orientation and monitoring, planning and evaluation might have been characterised less by highly interactive discussions focussed on challenging one's own and each other's point of view, but rather by quick consensus-building, for example aimed at efficient problem solving (Weinberger & Fischer, 2006). Additionally, tutors' pedagogical responsibility towards the RPT-group might have given them the status of decision-maker during planning and evaluation (Robinson et al., 2005; Webb, 2009), whereas tutees possibly perceived monitoring and orientation more easily as a shared responsibility, given their experienced need to control their understanding and prior knowledge when discussing learning content with peers. Consequently, tutees' perceptions on tutors' responsibilities might have prevented them from challenging tutors' proposed problem solving plan or evaluative judgements, possibly limiting the chances for multiple tutees to engage in reciprocal discussions and socially shared regulative acts during planning and orientation.

Limitations of the present study

Although the present study adds valuable results to the emerging research on SSMR, its limitations should equally be acknowledged. Since the research was conducted in a particular collaborative learning context, with a rather small sample of RPT-groups, its findings should be cautiously interpreted, for they might not be representative for collaborative learners' metacognitive regulation behaviour in other settings.

The present study demonstrated that investigating metacognitive regulation based on students' actual regulation behaviour in authentic settings, more specifically, collaborative learners' adoption of SSMR, remains methodologically challenging (Molenaar & Järvelä, 2014; Vauras & Volet, 2013). Although we succeeded in unfolding time-bound evolutions in RPT-groups' adopted metacognitive regulation foci, including their SSMR, long-term developmental data is needed to fully understand and optimally promote collaborative learners' (socially shared) metacognitive regulation (Molenaar & Järvelä, 2014; Perry & Winne, 2013). Longitudinal designs require, nevertheless, larger and more representative samples, whereas the time-and labour-intensive nature of coding and analysing thick dialogue data puts constraints on the sample size (Järvenojä et al., 2013; Volet et al., 2013). Assessment of RPT-groups' metacognitive regulation in the present study was moreover exclusively based on students' verbalised metacognitive actions, while it can be assumed that students do not always articulate their (regulative) reasoning. This implies that the measurement of RPT-groups' adopted metacognitive regulation skills and approaches was probably not exhaustive for all metacognitive utterances. Moreover, given that SSMR is frequently demonstrated in non-verbal interactions (Iiskala et al., 2011; Volet et al., 2013), the current study's identification of RPT-groups' regulative foci was probably not complete either. It should further be noted that by focusing on the occurrence of RPT-groups' regulative foci, the present study could not grasp the dynamics of RPT through which social forms of metacognitive regulation, more especially SSMR, emerged (Molenaar & Järvelä, 2014). Data-triangulation by means of social network analysis could have compensated for this (Hurme et al., 2006; Järvenojä et al., 2013). Visualisation of the collaborative learning process could have unravelled how SSMR was elicited, shaped, maintained, and refined through RPT-participants' social interactions.

Additionally, it should be acknowledged that peers' interactions are generally influenced by characteristics of the collaborative learning setting (Volet et al., 2009b; Webb, 2009). The possible influence of the latter on RPT-groups' evolving (socially shared) metacognitive regulation behaviour was, however, not taken into account in the present study. It remains consequently unclear whether RPT-participants' growing adoption of a socially shared regulation focus is connected to particularities of the RPT-setting (e.g. dynamics between tutors and tutees, changes in peer tutors' academic support, participants' perceptions on tutors' versus tutees' responsibilities and corresponding social status, group assignments directed at deepening students' content-specific knowledge, etc.) or whether the portrayed evolutions in SSMR can be identified in other PT-formats or non-tutoring control groups as well. It seems, for example, plausible that cross-age peer tutors in a fixed format (in which tutor and tutee roles are not alternated – Topping, 2005) might model metacognitive regulation more explicitly (Duran & Monereo, 2005), which might evoke tutees' regulative contributions and the group's SSMR less easily. Furthermore, examination of students' regulation behaviour during computer-supported peer tutoring might also unfold different evolution patters in students' regulative foci, given that online peer discussions are frequently shallow, short, and non-reciprocal (Pifarré & Cobos, 2010). The absence of a baseline to compare the currently unravelled RPT-participants' SSMR with, makes it rather difficult to assess the value and effectiveness of peer tutoring to foster SSMR.

Directions for future research on SSMR

Since the research on SSMR is still in its infancy, many directions for future studies can be put forward. In the following paragraph, we set out an agenda for future research on SSMR based on both the findings and limitations of the present study.

The present study focussed exclusively on RPT-participants' metacognitive regulation behaviour, without taking into account the impact of SSMR on RPT-participants' learning outcomes. Although it is widely assumed that adopting a socially shared regulation focus advances collaborative learners' problem solving and results in productive learning outcomes, there is only limited empirical evidence confirming this hypothesis (e.g. Järvelä et al., 2013; Khosa & Volet, 2014). Future research is therefore needed to investigate whether and how adopting SSMR benefits both individual students' and the collaborative learning group's learning, implying learning measures (e.g. measures of domain-specific learning gains, academic achievement, cognitive reasoning, content processing, etc.) should be included as output-related variables in future research designs (Molenaar & Järvelä, 2014; Rogat & Adams-Wiggins, 2014). Given that results on the impact of collaborative learning processes (e.g. SSMR) on group-related outcomes and on individual group members' learning are sometimes conflicting (Kirschner, Paas, & Kirschner, 2009; Michinov & Michinov, 2009), it would further be interesting to examine whether the effects of SSMR on RPT-groups' learning outcomes are also transferable to individual RPT-participants. This is in line with the current call for assessing metacognitive regulation simultaneously at the individual learner level and at the group level and for examining the dynamic interplay between both levels (Grau & Whitebread, 2012; Khosa & Volet, 2014; Perry & Winne, 2013). It would in this respect also be interesting to go beyond the present study's conceptualisation of SSMR as a specific type of metacognitive regulation along the social spectrum and to examine whether SSMR can equally be interpreted as a transitional phase towards (optimised) self-regulation (DiDonato, 2013).

Although the present study extended prior research on SSMR by investigating whether particular regulation skills and approaches facilitate or rather hamper RPT-groups' adoption of a socially shared regulation focus, it can be assumed that other aspects of the collaborative learning setting or individual students' characteristics could be equally or even more influential for RPT-groups' SSMR (Khosa & Volet, 2014; Molenaar & Järvelä, 2014; Rogat & Adams-Wiggins, 2014). Future research preferably aims at studying alternative (e.g. socio-emotional, communicative, or cognitively-oriented) correlates of collaborative learners' adoption of SSMR. Positive socio-emotional peer interactions, characterised by active listening, supportive help giving, and group cohesion, might for example facilitate SSMR, whereas negative socio-emotional peer interactions might generate a negative impact (Rogat & Linnenbrink-Garcia, 2011; Volet et al., 2009a). Correspondingly, collaborative learners' prior relationships might affect the way they interact and share learning or regulation activities (Webb et al., 2006). Additionally, it could be that the reciprocity of peers' interactions determines students' involvement in SSMR. It might therefore be relevant to include the level of transactivity in RPT-groups' discussions (Weinberger & Fischer, 2006) as a mediating variable. In line with this, RPT-groups' strategies to process the learning content might influence their SSMR (Khosa & Volet, 2014; Volet et al., 2009a). Higher-order processing, characterised by elaborative conceptual discussions aimed at shared meaning making (Roscoe & Chi, 2008), might promote SSMR, whereas lower-order processing, focussed on factual knowledge acquisition might rather hamper it. Future research could further investigate whether low- versus high-achievers, poorly versus highly motivated students, or novices versus students with enlarged domain-specific expertise take a different social position in the collaborative learning group and how this affects their engagement in SSMR with other students (Iiskala et al., 2011; Rogat & Adams-Wiggins, 2014; Volet et al., 2013), as learner characteristics were not included as mediating variables in the present study. It should further be noted that productive collaborative learning is also likely to be influenced by the task at hand and the group's constructed cognitive system when tackling this task (Iiskala et al., 2011; Kirschner et al., 2009). The open-ended group assignments aimed at profound knowledge co-construction in the current study might have facilitated RPT-groups' adoption of SSMR given that their complex nature probably demanded for intensive conceptual discussions and coordination of joint problem solving, which might have encouraged students into SSMR (Hurme et al., 2006; Kirschner et al., 2009). On the other hand, easy tasks aimed at recalling information might invite collaborative learners less into reciprocal discussions and shared regulative acts (Iiskala et al., 2011; Perry & Winne, 2013). Future research on the differential impact of easy versus complex task types on collaborative learners' adoption of SSMR would therefore be relevant. Additionally, the possible impact of RPT-groups' cognitive system, including their experienced cognitive load, should be acknowledged (Kirschner et al., 2009). Collaboratively solving complex tasks allows students to share and divide the cognitive load encountered when processing new knowledge (Kirschner et al., 2009). On the one hand, this might foster students' learning and increase their SSMR, given that a larger part of the group's cognitive working space becomes available for mutually regulating the group's learning and optimising adopted SSMR-strategies. On the other hand, previous research demonstrated that collaborative learners often face difficulties in successfully sharing regulative acts with multiple students, implying that adopting a socially shared regulation focus is rather complex (Rogat & Linnenbrink-Garcia, 2011; Volet et al., 2009a). Consequently, coordinating collective problem solving in combination with jointly regulating interpersonal activities might as well add cognitive load to the collaborative working space, possibly inhibiting productive learning (Kirschner et al., 2009). Future research is needed to unravel the complex relationship between collaborative learning (outcomes), cognitive load, and SSMR.

Last, it should be noted that the present study merely portrayed time-bound evolutions in RPT-groups' SSMR based on the occurrence of shared regulative acts. Future studies should, nevertheless, also aim to identify quality differences in adopted SSMR-strategies, as well as investigate whether high-quality SSMR correlates with improved group performance or a deeper understanding (Järvelä et al., 2013; Rogat & Linnenbrink-Garcia, 2011). Utterances of poor versus high quality SSMR could for example be conceptualised based on the low versus high level of regulative synergy among all collaborative learners, the undermining versus facilitating impact of SSMR on the collaborative learning process; the negative versus positive social-emotional relations among collaborative learners; and the degree to which students merely represent versus elaboratively operate on each other's regulative acts (Iiskala et al., 2011; Rogat & Adams-Wiggins, 2014; Volet et al., 2009a).

Conclusion

Although many questions remain unanswered in the emerging research on (socially shared) metacognitive regulation during collaborative learning, the present study adds valuable insights to our understanding of the evolving adoption of collaborative learners' regulation focus, including their engagement in SSMR. By unravelling some correlates of SSMR, taking into account particular regulation skills and approaches, the present research furthermore offers innovative insights on how to optimise SSMR. This allows the research community to take a further step, by conducting studies exploring the impact of instructional interventions on collaborative learners' SSMR, to enhance successful collaborative learning.

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Appendix A Examples of coded regulative foci

Excerpt from RPT-discussion	Focus of metacognitive regulation
T: “Tina, can you remember the characteristics of constructivism?” t1: “Active learners and coaching teachers.” T: “Okay. And which type of learning is desired?” t1: “Discovery learning?” T: “Indeed! What should the teacher do to establish discovery learning, Tina?”	orientation (prior knowledge activation)
t2: “Tutor, sorry to interrupt, but apart from discovery learning there was another type... I cannot remember the name.” T: “Experiential learning?” t2: “Yes! And was the constructivist teacher called facilitator?” T: “Indeed!”	orientation (prior knowledge activation)
t3: “Okay, only 30 minutes left. Maybe it is wise to start the last subtask?”	monitoring (of progress)
t1: “But… The teacher was guiding practitioner, right? I don’t get…What is the difference with facilitator?” T: “Someone who can help?” t4: “Guiding practitioner is directive compared to the facilitator, not so? At the start the teacher guides, but he facilitates as students are more experienced in active learning, right?” t2: “Hmm...Aren’t both synonyms? Taken from different authors but basically implying the same, no? Teachers design learning environments to foster discovery learning, no?” t3: “Sounds good! And learners need some kind of support, so teachers guide and model… being a guiding practitioner, right?” t4: “Bob, you have your handbook. May you check whether our interpretation is correct?” T: “I think that’s wise because modelling and coaching are two different styles according to me. What’s in the handbook?” t2: *[reads information from the handbook out loud]* t1: “Okay so, basically a constructivist teacher promotes active student learning and his actions are labelled as both facilitating and guiding practitioner, not so? ” t4: “Or acting as a coach, not so?” t2: “I think. But modelling is different… at least I think so.”	monitoring (of comprehension)
t3: “Okay, I wrote that in our report. Shall I read it so that you can check the correctness? (...)	monitoring (of progress)

Note: T: tutor; t: tutee; individually-oriented metacognitive regulation; tutor-prompted co-regulation; tutee-prompted co-regulation; SSMR

6

Eliciting reciprocal peer tutoring groups' metacognitive regulation through structuring and problematising scaffolds

This chapter is based on:

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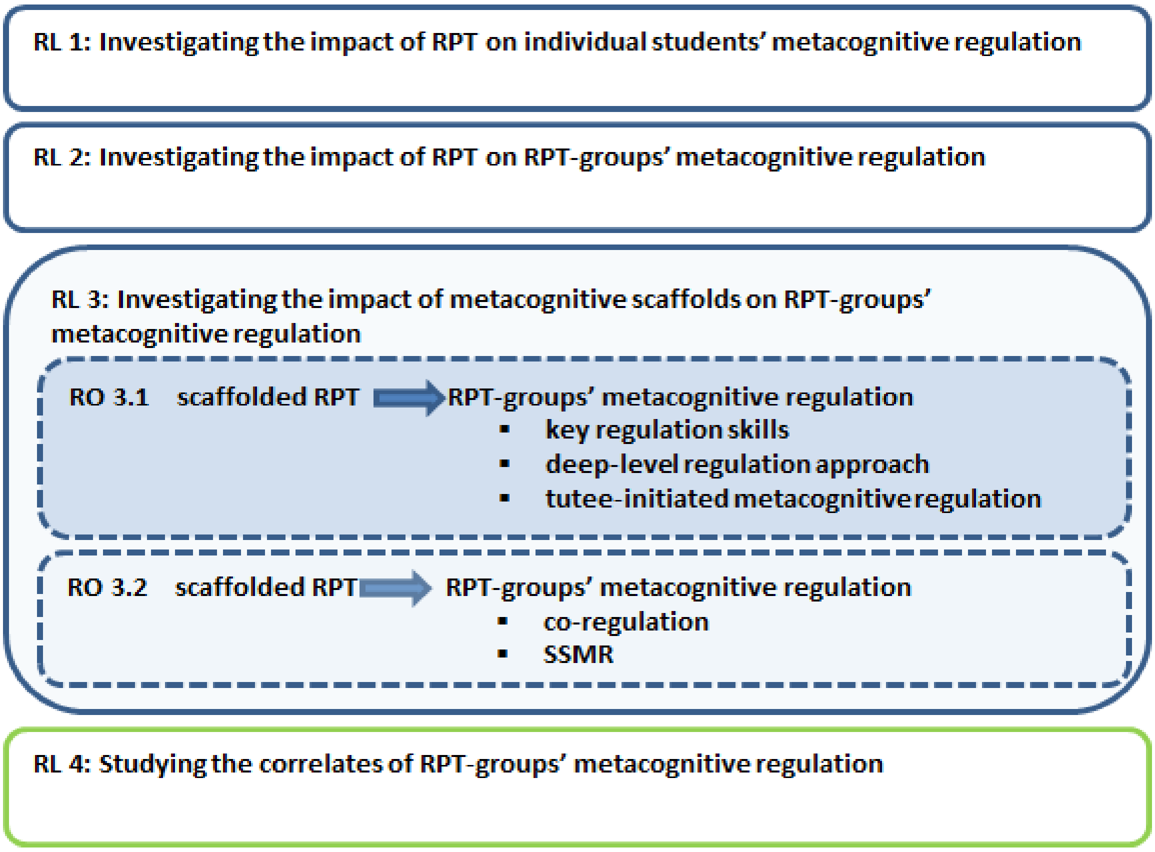

Figure 1. Chapter 6 in relation to the research lines of the dissertation

Chapter 6

Eliciting reciprocal peer tutoring groups' metacognitive regulation through structuring and problematising scaffolds

Abstract

The present study examines whether structuring (SS) versus problematising scaffolds (PS) affect higher education reciprocal peer tutoring (RPT) groups' adoption of particular regulation skills, deep-level regulation, and tutee-initiated regulation, differently. A quasi-experimental design involving two experimental groups (SS-condition versus PS-condition) was adopted. The first, third, and sixth RPT-session of eight randomly selected RPT-groups (four from the SS-condition, four from the PS-condition) were videotaped (48h). Mixed ANOVA's were conducted to investigate the differential impact of both scaffold types on RPT-groups' metacognitive regulation. The results indicate that neither scaffold type encourages RPT-groups into a balanced adoption of or initiative for regulation skills and a deep-level approach. Nevertheless, the PS-condition significantly outperforms the SS-condition in evoking deep-level monitoring, tutee-initiated orientation, and tutee-initiated monitoring.

Introduction

Collaborative learning is assumed to facilitate students' adoption of metacognitive regulation (Hadwin, Miller, & Järvelä, 2011; Manlove, Lazonder, & de Jong, 2007; Vauras & Volet, 2013). Conceptual peer discussions and joint problem solving encourage collaborative learners to discuss and agree upon both the content and the organisation of their collective learning activities, directly addressing their metacognitive regulation. However, students in open-ended collaborative learning environments often encounter difficulties to spontaneously apply adequate metacognitive regulation skills, and hence fail to achieve satisfactory learning outcomes (Bannert & Reimann, 2012; Manlove et al., 2007; Veenman, Elshout, & Busato, 1994). Enhancing the quality and outcomes of collaborative learning consequently demands for additional instructional guidance or supporting aids – i.e. scaffolds – which can invoke and advance collaborative learners' metacognitive regulation (Azevedo, & Hadwin, 2005; Lajoie, 2005; Pea, 2004). Metacognitive scaffolds assist students in identifying learning goals and task structures, selecting and revising problem solving strategies, and evaluating learning outcomes (Bannert & Mengelkamp, 2008; Berthold, Nückles, & Renkl, 2007). They operate as catalysts, allowing students to activate metacognitive regulation skills which would not have been recalled or executed spontaneously (Azevedo, Cromley, Winters, Moos, & Greene, 2005; Bannert & Reimann, 2012; Hoffman & Spatariu, 2008). Despite general agreement about the benefits of scaffolding students' metacognitive regulation when learning collaboratively in complex, open-ended learning environments, there is little clarity as to which types of scaffolds are most effective in supporting students' adoption of particular regulation skills (Azevedo & Hadwin, 2005; Fiorella, Vogel-Walcutt, & Fiore, 2012). The present study therefore investigates how the metacognitive regulation behaviour of university students collaborating in a reciprocal peer tutoring (RPT) setting, can be promoted. It more specifically aims at examining the impact of both structuring and problematising scaffolds (Reiser, 2004) on RPT-groups' adoption of particular regulation skills, their deep-level regulation approach, and tutees' initiative for regulating the group's learning. By identifying the instructional value of structuring versus problematising scaffolds, the present study provides valuable guidelines on how to optimally support collaborative learners' metacognitive regulation in higher education.

Theoretical underpinnings

Metacognitive regulation: skills and approaches

Metacognitive regulation refers to regulatory skills and strategies used by learners to control, coordinate, and regulate their personal, a collaborating peer's, or the group's learning process (Hadwin et al., 2011; Meijer, Veenman, & van Hout-Wolters, 2006). We distinguish between orienting, planning, monitoring, and evaluating as key regulation skills (Brown, 1987; De Backer, Van Keer, & Valcke, 2012; Veenman, Elshout, & Meijer, 1997). When orienting, collaborative learners engage in task analysis and prior knowledge activation, to get acquainted with both learning objectives and each other's initial understanding (Butler, 2002). Planning encompasses selecting and sequencing problem solving strategies and developing action plans to tackle the group assignment (Meijer et al., 2006). Monitoring involves the quality control of the collaborative problem solving process, aimed at identifying inconsistencies and at optimising task execution (Meijer et al., 2006; Webb, 2009). It can be directed at students' comprehension, progress, or collaboration (Hurme, Palonen, & Järvelä, 2006; King, 1998; Veenman et al., 1997). Evaluation involves learners' self-judgements upon completion of collaborative learning, focussed on learning outcomes, the problem solving process, or group members' collaboration (Butler, 2002; Meijer et al., 2006).

Since collaborative learners' metacognitive regulation is linked to their lower- versus higher-order content processing and their learning approach (King, 1998; Volet, Summers, & Thurman, 2009), we distinguish low-level versus deep-level metacognitive regulation (De Backer, Van Keer, & Valcke, in press b). Low-level orientation is directed at exploring task demands, whereas deep-level orientation aims at processing task demands and activating prior knowledge (Butler, 2002). Low-level planning implies the development of a single action plan for problem solving, whereas deep-level planning involves selecting an approach from problem-solving alternatives (Meijer et al., 2006; Veenman et al., 1997). When students check the group's progress, collaboration, or their own or peers' understanding, they engage in low-level monitoring. Reflective comments on the quality of the group's collaboration or perceived progress and elaborative control of one's comprehension imply deep-level monitoring (Roscoe & Chi, 2008). Correspondingly, low-level evaluation involves checking and commenting on either learning outcomes or process factors, whereas deep-level evaluation implies reflective judgments on both (Veenman et al., 1997).

Eliciting metacognitive regulation during peer tutoring

The present study examines the metacognitive regulation behaviour of collaborative learners participating in reciprocal peer tutoring. Peer tutoring (PT) is characterised by active academic helping and supporting between peers in small groups or student pairs (Falchikov, 2001; Topping, 2005). One peer, the tutor, takes a direct pedagogical responsibility by creating learning opportunities through questioning, clarifying, and active scaffolding (Duran & Monereo, 2005; Roscoe & Chi, 2008). The students being cognitively challenged by this tutor, are called tutees. Reciprocal peer tutoring (RPT) in particular, is characterised by the structured exchange of the tutor role among peers in the PT-pair/group (Duran & Monereo, 2005) and enables each student to experience the benefits of providing and receiving academic guidance (Falchikov, 2001; Topping, 2005).

The open learning environment established in a PT-setting invites students to take responsibility for their own and their peers' learning, including metacognitively regulating the collaborative learning process. Although peer tutors often tend to dominate the tutorial process by instructing tutees into content processing or metacognitive regulation (Roscoe & Chi, 2008), their support generally evolves over time, invoking more tutee-centred learning (De Smet, Van Keer, & Valcke, 2009; Hadwin, Wozney, & Pontin, 2005). Whereas the peer tutor initially acts as a model, initiating and controlling tutees' learning and the group's regulation, he is expected to operate as tutees' coach once they gain more competence in the PT-setting (Rasku-Puttonen, Eteläpelto, Arvaja, & Häkkinen, 2003). A coaching peer tutor indirectly prompts tutees' learning while tutees start to initiate the tutorial discussions and metacognitive regulation becomes a shared responsibility among tutor and tutees (Hadwin et al., 2005; Pata, Sarapuu, & Lehtinen, 2005; Rasku-Puttonen et al., 2003). Ultimately, the peer tutor's support fades out as he takes the role of consultant, merely fine-tuning the collaborative learning process since tutees have taken full ownership of their own and each other's learning (De Smet et al., 2009; Hadwin et al., 2005).

A PT-setting allows for intensive metacognitive modelling and individualised feedback on internalised regulation skills, which might foster metacognitive regulation (Hadwin et al., 2005; King, 1998). Nevertheless, its open-ended design also faces students with challenges to spontaneously execute the regulation skills which are required for optimal collaborative learning (Azevedo & Hadwin, 2005; Bannert & Reimann, 2012; Manlove et al., 2007). Prior research demonstrated that RPT is fruitful for students' spontaneous adoption of metacognitive regulation, however also revealed a dominant involvement in comprehension monitoring, low-level regulation, as well as limited tutee-initiative for regulating the group's learning (De Backer, Van Keer, Moerkerke, & Valcke, in press a). Consequently, a more balanced engagement in all metacognitive regulation skills and larger shifts towards both deep-level and tutee-initiated regulation appear to demand for additional instructional support, assisting RPT-participants in adequately demonstrating the required regulation behaviour (Berthold et al., 2007; Lajoie, 2005; Pea, 2004). Metacognitive scaffolds direct students' attention towards particular regulative acts and might therefore help to overcome students' difficulties of regulating collaborative learning adequately in complex, open-ended learning environments (Bannert & Reimann, 2012; Hmelo-Silver & Azevedo, 2006).

Scaffolding: original versus recent conceptualisation

Scaffolding is intended to facilitate learning and regulation (Azevedo & Hadwin, 2005; Berthold et al., 2007). Introduced by Wood, Bruner, and Ross (1976), the notion of scaffolding was originally conceptualised as dynamic assistance provided by a more knowledgeable person to a novice learner, aimed at helping the learner succeed in learning activities he is unable to successfully accomplish independently and at fading the assistance as the learner's competence increases (Collins, Brown, & Newman, 1989; Lajoie, 2005; Pea, 2004; Puntambekar & Hübscher, 2005). It concerns a delicate balance between on the one hand supporting students by channelling and focussing their learning or regulation and by modelling advanced learning behaviour, on the other hand actively engaging students in the learning process by encouraging them to internalise and apply the pursued learning and regulation strategies (Pea, 2004; Reiser, 2004). Scaffolding is associated with Vygotsky's (1978) notion of the zone of proximal development (ZPD), which is defined as the distance between what the learner could accomplish independently and a higher mastery level which could be accomplished when guided by a more capable other. In order to promote learning, scaffolding should be situated within a student's ZPD, enabling him to bridge the gap between his actual and potential competence (Pea, 2004; Puntambekar & Hübscher, 2005).

Originally, ongoing diagnosis, calibrated support, and fading concerned essential elements in the scaffolding process (Collins et al., 1989; Puntambekar & Hübscher, 2005; Wood et al., 1976). To assure dynamic support, students' changing levels of understanding should be diagnosed continuously (Azevedo & Hadwin, 2005). This should lead to calibrated support, appropriated to individual students' progressive understanding (Lajoie, 2005; Wood et al., 1976), which should be reduced or faded, as students become more capable of independent learning (Collins et al., 1989; Pea, 2004). However, with computer-based learning taking a central place in educational research, scaffolding has increasingly been narrowed to instructional (software) tools, designed to help students learn and regulate successfully (Azevedo et al., 2005; Puntambekar & Hübscher, 2005). This recent conceptualisation often abandons the intrinsically dynamic nature of scaffolding (as a verb), favouring the notion of "scaffold" (as a noun) to describe fixed prompts and hints which operate as strategy activators (Berthold et al., 2007), directing learners' attention and eliciting learning and regulation behaviour that students are capable of but do not demonstrate spontaneously (Hmelo-Silver & Azevedo, 2006; Pea, 2004). Metacognitive scaffolds should be considered as supportive aids and instructions that are embedded in the learning material, which require students to recall and carry out particular regulative acts (Bannert & Reimann, 2012; Choi, Land, & Turgeon, 2005; Hoffman & Spatariu, 2008). Their purpose is to support students in identifying objectives and task structures, activating prior knowledge, controlling their understanding, selecting and monitoring learning strategies, and evaluating learning outcomes (Fiorella et al., 2012; Veenman et al., 1994). Whereas metacognitive scaffolds have demonstrated their instructional value to enhance students' learning and understanding (e.g. Bannert & Mengelkamp, 2008; Choi et al., 2005; Hoffman & Sparatiu, 2008; Manlove et al., 2007), many questions regarding which types of support are most effective to evoke particular metacognitive regulation skills or approaches remain unanswered (Azevedo et al., 2005; Fiorella et al., 2012). The present study aims at examining whether structuring versus problematising scaffolds stimulate RPT-groups' metacognitive regulation differently.

Prompting metacognitive regulation through structuring and problematising scaffolds

Scaffold formats influence whether and how metacognitive regulation is stimulated (Bannert & Mengelkamp, 2008; Molenaar, van Boxtel, & Sleegers, 2010). Reiser (2004) distinguishes between scaffolds structuring and scaffolds rather problematising the learning process. Structuring scaffolds aim to reduce the complexity of open-ended problem solving by providing additional structure to the task (e.g. offering direct guidelines, exemplifying, or narrowing choices). By simplifying the learning environment, partly performing students' learning and regulation, structuring scaffolds directly reduce students' freedom and explicitly help them to maintain direction (Wood et al., 1976). Problematising scaffolds on the other hand are less directive for they merely suggest students to consider learning and regulation activities which they might otherwise overlook (Reiser, 2004). They are characterised by reflection-provoking prompts, marking critical task features and highlighting essential problem solving steps (Wood et al., 1976), challenging students to articulate their thinking and to take initiative for optimally shaping their learning. Although problematising scaffolds initially complicate the learning environment, encouraging students to face the complexity of learning also advances their future learning, due to generating productive and transferable learning and regulation strategies (Molenaar et al., 2010; Reiser, 2004).

Research hypotheses

The present study aims at investigating whether structuring and problematising scaffolds elicit RPT-groups' metacognitive regulation differently. More specifically, differences in the frequency of (a) adopted regulation skills; (b) a deep-level regulation approach; and (c) tutee-initiative for metacognitive regulation are examined. By merely suggesting regulation activities, problematising scaffolds are expected to provoke metacognitively-oriented discussions among RPT-participants more often than structuring scaffolds (Molenaar et al., 2010; Reiser, 2004), which stimulate to directly perform regulation as demonstrated in the scaffolds. Given that such discussions offer students a platform to apply metacognitive regulation skills and to encourage peers to equally contribute to the group's regulation (Hurme et al., 2006), we hypothesise that the frequency of occurrence of metacognitive regulation skills will be higher in the problematising scaffold (PS) condition compared to the structuring scaffold (SS) condition (hypothesis 1). Since metacognitive peer discussions stimulate students' feedback and reflections on each other's regulation (Hadwin et al., 2011; Iiskala et al., 2011), which might facilitate a deep-level regulation approach (Volet et al., 2009), we additionally hypothesise that the PS-condition will outperform the SS-condition in demonstrating deep-level regulation (hypothesis 2). Given their directive nature, we furthermore expect structuring scaffolds to stimulate tutor-initiated modelling of metacognitive regulation, whereas problematising scaffolds are hypothesised to create more opportunities for tutees to contribute to metacognitive discussions and to initiate the group's regulation (hypothesis 3).

Method

Participants and setting

The study was conducted in a naturalistic university setting. Fifty-eight first-year Educational Sciences students who already obtained a Professional Bachelor degree (5.3% males and 94.7% females) were randomly assigned to ten RPT-groups. The RPT-intervention was a formal component of the 5-credit course "Instructional Sciences". All RPT-participants were involved in the study.

Design

A quasi experimental design was adopted, involving two experimental conditions. Five randomly selected RPT-groups were assigned to a structuring scaffold (SS) condition, whereas five other RPT-groups were randomly assigned to a problematising scaffold (PS) condition. All aspects of the RPT-intervention were identical in both conditions, except for the type of scaffolds provided to the RPT-groups. Whereas RPT-groups in the SS-condition were given direct guidelines to engage in particular regulation skills, RPT-groups in the PS-condition were offered reflection-provoking prompts, encouraging them to discuss and apply particular regulation skills. Both types of scaffolds were embedded in the learning material (i.e. RPT-assignments), urging students to take them into account (Manlove et al., 2007). The scaffolds in both conditions were furthermore provided at the same time within the problem solving process and addressed identical regulation skills. Each RPT-assignment integrated the same scaffolds throughout the complete intervention. Appendix A provides an overview of all scaffolds presented in both conditions.

RPT-intervention

The RPT-intervention consisted of eight successive face-to-face sessions (including a training session) of 2 hours each, in which students tutored one another in small and stable groups of six. The tutor role was randomly appointed to students by a university staff member and interchanged at each session within each RPT-group. During each RPT-session, the tutor was primarily responsible for managing the interactions and stimulating collaborative learning, whereas tutees were occupied with solving the group assignment. As a manipulation check, all RPT-groups were observed weekly, to control whether tutors and tutees enacted their roles adequately and RPT-groups adopted the scaffolds as intended.

Assignments

During each RPT-session, students worked on authentic group assignments, linked to themes in the course “Instructional Sciences” (see De Backer et al., 2012). The assignments were presented as open-ended tasks requiring students’ collaboration and high levels of cognitive processing. Each assignment consisted of an outline of learning objectives; a subtask to get familiar with theme-specific terminology; and a subtask to apply theory to real-life cases. Despite differences in the central topic, all assignments addressed comparable learning experiences during each RPT-session.

Training

Students participated in a compulsory tutor training, one week before the onset of the RPT-intervention. During this training, they were informed about the multidimensional responsibilities of the peer tutor and were taught a mix of generic tutoring skills. The focus was more specifically on establishing a safe learning climate, managing and stimulating interactions, asking differentiated questions, giving constructive feedback and providing comprehensive explanations (Chi, Siler, Jeong, Yamauchi, & Hausmann, 2001; Falchikov, 2001; King, 1998; Roscoe & Chi, 2008; Webb, 2009). The tutor training was summarised in a manual provided to each tutor.

Tutor guide

To prepare themselves, peer tutors received a session-specific “tutor guide” one week in advance. This guide consisted of a 10-page manual and offered additional information about the theory to focus upon in the RPT-session, for the PT-literature stresses the necessity of a difference in peer tutors’ and tutees’ domain-specific knowledge (Falchikov, 2001; Topping, 2005). Additionally, the tutor guide inspired students to tackle the problem solving process stepwise, by offering examples to explore task demands, develop actions plans, verify whether task requirements are met, and reflect on the RPT-session. These problem solving steps were depicted in a schematic overview, provided to each tutor (De Backer et al., 2012).

Interim support

To provide support to students, both interim supervision sessions (taking two hours) and two-weekly feedback sessions (each taking 30 minutes) were organised. Halfway through the RPT-intervention, compulsory supervision sessions were organised for all students. The supervision sessions were set up in small groups of twelve students (recruited from two randomly selected RPT-groups) and directed by a staff member, who encouraged students to reflect on their behaviour as tutor and tutee. Additionally, the staff member provided group-specific feedback every two weeks, focusing on group dynamics, peer collaboration, equal contribution of tutees, and students' tutoring approach. The feedback resulted in group reflections and action plans to optimise peer collaboration.

Data collection

The first (at the start), third (halfway) and sixth (upon completion) RPT-session of eight randomly selected RPT-groups of six students (i.e. four groups/24 students from the SS-condition and four groups/24 students from the PS-condition) were videotaped (i.e. 48 hours of video recordings). The video data provided real-time information about tutors' and tutees' learning activities, including their metacognitive regulation behaviour.

Coding instrument

Utterances of metacognitive regulation were identified using the RPT_MCR instrument (i.e. RPT-groups' metacognitive regulation; De Backer et al., in press a), which incorporates literature on both metacognitive regulation (e.g. Meijer et al., 2006; Veenman et al., 1997) and tutoring/peer interactions (e.g. King, 1998; Roscoe & Chi, 2008; Webb, 2009). The instrument represents a multi-layered model of metacognitive regulation in collaborative settings. Orientation, planning, monitoring, and evaluation are adopted as the main coding categories and specified with sub-coding categories (i.e. task analysis, activating prior knowledge, task perceptions, planning in advance, interim planning, monitoring of comprehension, monitoring of progress, monitoring of collaboration, evaluation of learning outcomes, evaluation of the learning process, and evaluation of collaboration). Additionally, a dimension on the approach to metacognitive regulation is included, identifying the low- versus deep-level nature of regulation strategies in the sub-coding categories. Both the metacognitive strategies and the regulative approaches are developed from the literature on metacognitive regulation, as presented in the theoretical part of this article.

Coding strategy

The coding procedure followed subsequent phases and was exclusively focussed on students' verbalised interaction. First, peer discussions in each RPT-session were divided into broad segments by means of episode coding, according to changes in the topic of discussion (Chi et al., 2001). An episode is conceptualised as a rather large segment (including multiple conversational turns) of the overall interaction that was centred around one particular topic of discussion. After segmentation, each episode was labelled as either metacognitive regulation, task execution (i.e. problem solving or knowledge transmission), or off-task behaviour. Second, metacognitive episodes were reanalysed for more detailed statement coding at the turn level (Roscoe & Chi, 2008). A statement (representing a single conversational turn) refers to a single thematically consistent verbalisation of a single metacognitive action by a single student. Each metacognitive statement was given a code from the RPT_MCR instrument, indicating (a) the general regulation skill it addressed (i.e., orientation, planning, monitoring, and evaluation); (b) the more concrete regulation strategy it represented (i.e. task analysis, activating prior knowledge, task perceptions, …); and (c) the low- versus deep-level approach it reflected. Last, metacognitive statements were analysed further to check whether they were initiated by the tutor or by a tutee. Depending on the initiative taker, metacognitive statements received the code 'tutor-initiative' versus 'tutee-initiative'[1].

The coding of the video data was accomplished by two independent and trained coders. They were blind to both the scaffold conditions and RPT-sessions. The coders double-coded 20% of the recorded sessions to determine interrater reliability. Cohen's kappa indicates high interrater reliability for the coding of 'metacognitive regulation' (κ = .87), and good agreement beyond chance for the four main coding categories ($\kappa_{orientation}$=.83, $\kappa_{planning}$ =.91, $\kappa_{monitoring}$ =.86, and $\kappa_{evaluation}$=.87). The interrater reliability for the coding of 'approach to metacognitive regulation' ($\kappa_{approach\_regulation}$=.92) and 'initiative for metacognitive regulation' ($\kappa_{initiative\_regulation}$=.95) was equally high.

Data analysis

After coding the video data, the frequency of occurrence of the different metacognitive regulation skills and approaches, as well as of regulative initiative-taking of tutors and tutees was calculated for each RPT-group and RPT-session. These frequencies were used for analysis purposes. To investigate whether structuring and problematising scaffolds generated a differential impact on RPT-groups' adoption of particular regulation skills (hypothesis 1), involvement in deep-level regulation (hypothesis 2), and tutees' initiative for regulation (hypothesis 3), a two-way mixed ANOVA[2] was performed for each metacognitive regulation skill, using research condition (SS/PS) as a between-subjects factor and measurement occasion (first/third/sixth RPT-session) as a within-subjects factor[3].

[1] Apart from the codes 'tutor-initiative' and 'tutee-initiative', a code 'reaction to tutor/tutee' was distinguished, for those metacognitive statements which were not newly initiated, but concerned a reaction to a previous comment by a peer. Metacognitive utterances with this code were not included in the data analysis, which explains why the aggregated proportion of tutor- and tutee-initiative for regulation in Table 2 does not equal 100%.

[2] Despite the rather small sample size, preliminary analyses demonstrated that the variables were normally distributed. We therefore opted to conduct mixed ANOVA's instead of non-parametric tests, especially since the latter (which were also run) did not yield different results.

[3] It should be noted that regulative skills, approaches, and initiative-taking with an average occurrence of less than 2% in Table 1 and Table 2 were excluded from mixed ANOVA.

When significant interaction effects of research condition and measurement occasion were found, repeated within-subject contrasts were carried out to examine trends from the first to the third RPT-session and from the third to the sixth RPT-session for both research conditions in more detail. Partial η^2 is reported as a measure of the effect size of significant differences in RPT-groups' metacognitive regulation behaviour in both research conditions. The significance level was .05 for all analyses.

Results

Descriptive analysis on RPT-groups' metacognitive regulation

Occurrence of regulation skills

In general, RPT-groups from the SS-condition and PS-condition demonstrate a similar adoption of particular regulation skills at RPT-session 1, 3, and 6. Table 1 reveals a dominant involvement in comprehension monitoring and (to a lesser extent) monitoring of progress, but a rather limited adoption of orientation, planning, and evaluation at RPT-session 1. RPT-groups in both research conditions evolve towards increased engagement in orientation (i.e. prior knowledge activation) and evaluation (i.e. of the learning process) at RPT-session 3 and 6 (see Table 1). Despite enhanced adoption of monitoring at RPT-session 3 and 6, the evolution in monitoring is smaller compared to the trends in RPT-groups' orientation and evaluation (see Table 1). In contrast, the frequency of occurrence of planning is rather limited and remains stable throughout the RPT-intervention, for both research conditions.

Approach to regulation

Table 1 reveals that RPT-groups in both research conditions almost exclusively adopt low-level regulation at RPT-session 1. Although both conditions gradually evolve towards more deep-level regulation, the occurrence of a deep-level approach is higher in the PS-condition compared to the SS-condition, both at RPT-session 3 and 6. A deep-level approach is, however, not present in all regulation skills. Both deep-level planning and deep-level evaluation remain negligible throughout the RPT-intervention, in both research conditions (see Table 1). In contrast, RPT-groups' adoption of deep-level orientation (i.e. prior knowledge activation) grows from RPT-session 1 to RPT-session 6, both in the PS-condition and the SS-condition. Whereas RPT-groups in the PS-condition additionally engage more frequently in deep-level (comprehension) monitoring, RPT-groups in the SS-condition demonstrate a rather stable adoption of deep-level monitoring throughout the RPT-intervention (see Table 1).

Table 1. *Occurrence of (low-level and deep-level) metacognitive regulation during the three RPT-sessions in both research conditions (frequencies and percentages)*

Metacognitive regulation	**RPT-session 1**				**RPT-session 3**				**RPT-session 6**			
	SS		**PS**		**SS**		**PS**		**SS**		**PS**	
	freq.	*%*	*freq.*	*%*	*freq.*	*%*	*freq.*	*%*	*freq.*	*%*	*freq.*	*%*
OCCURRENCE OF REGULATION												
Orientation	**178**	**5.9**	**96**	**3.6**	**273**	**8.4**	**323**	**9.9**	**513**	**12.9**	**473**	**10.5**
Task analysis	24	0.8	10	0.4	31	1.0	20	0.6	39	1.0	26	0.6
Prior knowledge activation	152	5.0	81	3.0	237	7.2	299	9.2	468	11.7	445	9.8
Awareness of task perceptions	2	0.1	5	0.2	5	0.2	4	0.1	6	0.2	2	0.1
Planning	**210**	**7.0**	**205**	**7.6**	**267**	**8.2**	**293**	**8.9**	**234**	**5.9**	**288**	**6.4**
Planning in advance	41	1.4	32	1.2	26	0.8	29	0.8	44	1.1	52	1.1
Interim planning	169	5.6	173	6.4	241	7.4	264	8.1	190	4.8	236	5.3
Monitoring	**2559**	**84.7**	**2317**	**85.9**	**2543**	**78.2**	**2476**	**75.6**	**2858**	**72.0**	**3213**	**71.6**
Comprehension monitoring	1999	66.1	1911	70.8	1907	58.7	1902	58.0	2204	55.5	2556	57.0
Monitoring of progress	542	18.0	391	14.5	625	19.2	549	16.8	626	15.8	637	14.2
Monitoring of collaboration	18	0.6	15	0.6	10	0.3	25	0.8	28	0.7	20	0.4
Evaluation	**72**	**2.4**	**77**	**2.9**	**167**	**5.2**	**183**	**5.6**	**367**	**9.2**	**514**	**11.5**
Evaluating learning outcomes	22	0.7	10	0.4	54	1.7	45	1.3	149	3.8	178	4.0
Evaluating learning process	33	1.1	29	1.1	80	2.5	87	2.7	179	4.4	255	5.7
Evaluating collaboration	17	0.6	38	1.4	33	1.0	51	1.6	39	1.0	81	1.8
Total	**3019**	**100**	**2695**	**100**	**3249**	**100**	**3275**	**100**	**3972**	**100**	**4488**	**100**
APPROACH TO REGULATION												
Low-level (LL) orientation	19	0.6	8	0.3	23	0.7	8	0.2	19	0.5	15	0.3
LL planning	198	6.6	197	7.3	260	8.0	270	8.2	232	5.8	277	6.2
LL monitoring	2443	80.9	2193	81.4	2373	73.0	2234	68.2	2482	62.5	2632	58.6
LL evaluation	71	2.4	69	2.6	157	4.8	164	5.0	363	9.1	481	10.7
LL regulation total	**2731**	**90.5**	**2467**	**91.6**	**2854**	**86.5**	**2676**	**81.6**	**3342**	**77.9**	**3405**	**75.8**
Deep-level (DL) orientation	157	5.2	83	3.1	243	7.5	311	9.5	481	12.1	456	10.2
DL planning	12	0.4	8	0.3	7	0.2	23	0.7	2	0.1	11	0.2
DL monitoring	103	3.4	112	4.2	120	3.7	241	7.4	130	3.3	576	12.8
DL evaluation	1	0.0	8	0.3	10	0.3	19	0.6	4	0.1	33	0.7
DL regulation total	**273**	**9.0**	**211**	**7.9**	**380**	**11.7**	**594**	**18.2**	**617**	**15.6**	**1076**	**23.9**

Table 2. *Tutor- and tutee-initiated metacognitive regulation during the three RPT-sessions in both research conditions (frequencies and percentages)*

Initiative for regulation	**RPT-session 1**				**RPT-session 3**				**RPT-session 6**			
	SS		**PS**		**SS**		**PS**		**SS**		**PS**	
	freq.	*%*	*freq.*	*%*	*freq.*	*%*	*freq.*	*%*	*freq.*	*%*	*freq.*	*%*
Tutor-initiated regulation												
Orientation	70	2.3	38	1.4	107	3.3	101	3.1	180	4.5	91	2.0
Planning	82	2.7	102	3.8	111	3.4	131	4.0	134	3.4	128	2.9
Monitoring	526	17.4	411	15.3	578	17.8	501	15.3	865	21.8	831	18.5
Evaluation	20	0.7	22	0.8	57	1.8	52	1.6	147	3.7	186	4.1
Total	**698**	**23.1**	**573**	**21.3**	**853**	**26.3**	**785**	**24.0**	**1326**	**33.4**	**1236**	**27.5**
Tutee-initiated regulation												
Orientation	11	0.4	12	0.4	62	1.9	106	3.2	104	2.6	179	4.0
Planning	45	1.5	25	0.9	38	1.2	34	1.0	19	0.5	40	0.9
Monitoring	344	11.4	456	16.9	447	13.8	558	17.0	428	10.8	894	19.9
Evaluation	13	0.4	11	0.4	15	0.5	47	1.4	52	1.3	107	2.4
Total	**413**	**13.7**	**504**	**18.6**	**562**	**17.4**	**745**	**22.6**	**603**	**15.2**	**1220**	**27.2**
Tutee-initiated low-level (LL) regulation												
LL orientation	0	0	1	0.0	1	0.0	0	0.0	0	0	0	0.0
LL planning	44	1.5	24	0.9	36	1.1	33	1.0	19	0.5	40	0.9
LL monitoring	326	10.8	435	16.1	440	13.5	528	16.1	370	9.3	864	19.3
LL evaluation	13	0.4	9	0.3	14	0.4	39	1.2	32	0.8	101	2.3
Total	**383**	**12.7**	**469**	**17.3**	**491**	**15.0**	**600**	**18.3**	**421**	**10.6**	**1005**	**22.5**
Tutee-initiated deep-level (DL) regulation												
DL orientation	11	0.4	7	0.3	54	1.7	104	3.2	61	1.5	178	4.0
DL planning	1	0.0	1	0.0	2	0.1	1	0.0	0	0.0	0	0.0
DL monitoring	18	0.6	17	0.6	11	0.3	30	0.9	2	0.1	30	0.7
DL evaluation	0	0.0	2	0.1	1	0.0	4	0.1	0	0.0	6	0.1
Total	**30**	**1.0**	**27**	**1.0**	**68**	**2.1**	**139**	**4.2**	**63**	**1.6**	**214**	**4.8**

Initiative for regulation

In general, metacognitive regulation is mainly initiated by the tutor, both in the SS-condition and in the PS-condition (see Table 2). For both research conditions, increases in tutee-initiated orientation, monitoring, and (to a lesser extent) evaluation are demonstrated. Nevertheless, tutors' and tutees' initiative-taking for particular regulation skills differs in both conditions. Whereas all regulation skills in the SS-condition remain dominantly tutor-centred throughout the RPT-intervention, tutees in the PS-condition initiate orientation (i.e. prior knowledge activation) and (comprehension) monitoring more frequently at RPT-session 6, compared to tutors (see Table 2). As compared to the SS-condition, RPT-groups in the PS-condition furthermore show more tutee-initiated orientation, monitoring, and evaluation from the third RPT-session onwards (see Table 2). Tutees' initiative for planning remains limited in both research conditions. Table 2 further reveals that tutee-initiated deep-level regulation in the SS-condition is negligible throughout the RPT-intervention, for all regulation skills. In contrast, tutees in the PS-condition increasingly initiate deep-level orientation from RPT-session 1 to RPT-session 6.

Impact of structuring versus problematising scaffolds on the occurrence of metacognitive regulation

No significant interaction effect between research condition and measurement occasion is reported for RPT-groups' adoption of metacognitive regulation ($F(2,12)=2.09$; $p=.166$), neither for the adoption of particular regulation skills. Neither from the first to the third RPT-session, nor from the third to the sixth RPT-session, significant differences are revealed between the SS-condition and the PS-condition regarding the frequency of adopted orientation ($F(2,12)=0.99$; $p=.401$), planning ($F(2,12)=0.17$; $p=.845$), monitoring ($F(2,12)=2.74$; $p=.104$), or evaluation strategies ($F(2,12)=2.20$; $p=.154$). The results do reveal, however, a significant main effect of measurement occasion on the occurrence of metacognitive regulation ($F(2,12)=23.38$; $p=.002$; *partial* $\eta^2=0.79$). From the third to the sixth RPT-session, RPT-groups demonstrate significantly more metacognitive regulation (*mean difference*=242.00; $p=.043$). No significant difference is revealed from the first to the third RPT-session (*mean difference*=101.25; $p=.199$).

Impact of structuring versus problematising scaffolds on the adoption of deep-level regulation

A significant interaction effect of research condition and measurement occasion is shown for RPT-groups' involvement in deep-level regulation ($F(2,12)=9.31$; $p=.004$; *partial* $\eta^2=0.61$). Figure 2a more specifically demonstrates that the PS-condition outperforms the SS-condition in applying deep-level (comprehension) monitoring from the third to the sixth RPT-session ($F(1,6)=21.43$; $p=.004$; *partial*

η^2=0.71). No significant difference is shown from the first to the third RPT-session (p=.139). A significant interaction effect of research condition and measurement occasion for RPT-groups' involvement in deep-level orientation could not be reported (F(2,12)=1.16; p=.162).

Impact of structuring versus problematising scaffolds on tutees' initiative for regulation

A significant interaction effect of research condition and measurement occasion is shown for tutees initiating metacognitive regulation (F(2,12)=8.17; p=.006; *partial* η^2=0.57). Figure 2b and Figure 2c more specifically reveal that the PS-condition demonstrates significantly more tutee-initiated orientation (F(2,12)=3.55; p=.016; *partial* η^2=0.37) as well as more tutee-initiated monitoring (F(2,12)=6.06; p=.015; *partial* η^2=0.50), compared to the SS-condition. From the first to the third RPT-session, tutees in the PS-condition initiate orientation (i.e. prior knowledge activation) significantly more, compared to tutees in the SS-condition (F(1,6)=6.18; p=.047; *partial* η^2=0.30), whereas no significant difference is revealed from the third to the sixth RPT-session (p=.414). In contrast, RPT-groups in the PS-condition show significantly more tutee-initiated monitoring (i.e. comprehension monitoring and monitoring of progress) from the third to the sixth RPT-session, as compared to RPT-groups in the SS-condition (F(1,6)=6.54; p=.043; *partial* η^2=0.52), whereas no significant difference in tutee-initiated monitoring is shown from the first to the third RPT-session (p=.297).

Further, a significant interaction effect of research condition and measurement occasion is reported for tutee-initiated deep-level regulation (F(2,12)=9.20; p=.004; *partial* η^2=0.60). Figure 2d more specifically reveals that tutees in the PS-condition significantly outperform tutees in the SS-condition regarding the initiative for deep-level orientation (i.e. prior knowledge activation) from the first to the third RPT-session (F(1,6)=6.34; p=.045; *partial* η^2=0.51). No significant difference is shown from the third to the sixth RPT-session (p=.062).

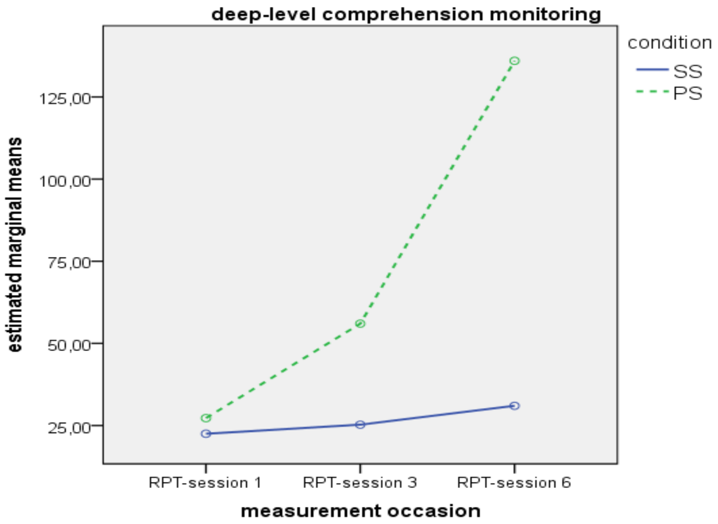

Figure 2a. Change in deep-level comprehension monitoring

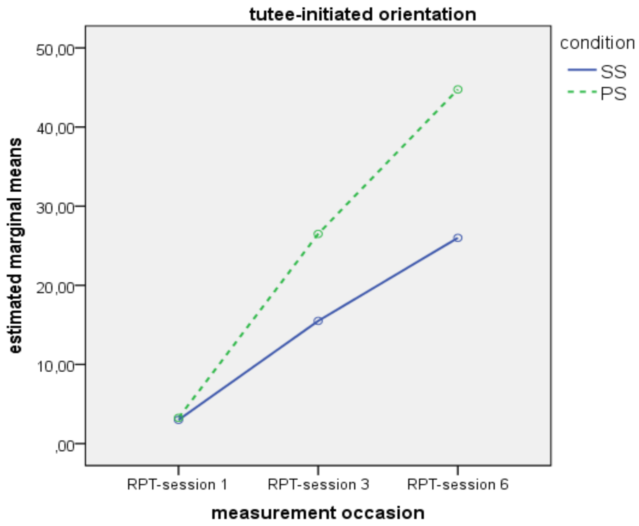

Figure 2b. Change in tutee-initiated orientation

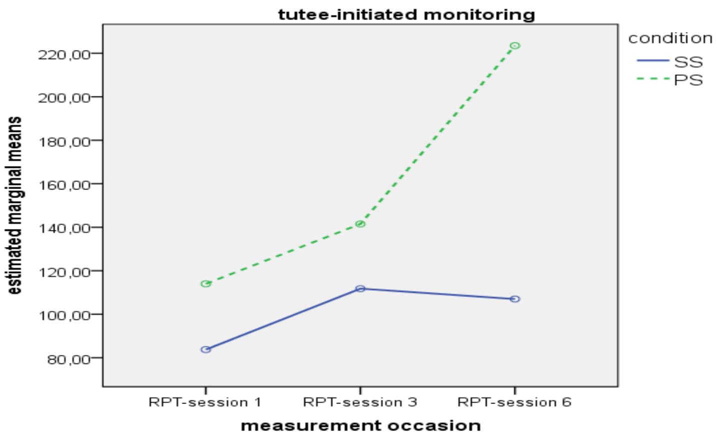

Figure 2c. Change in tutee-initiated monitoring

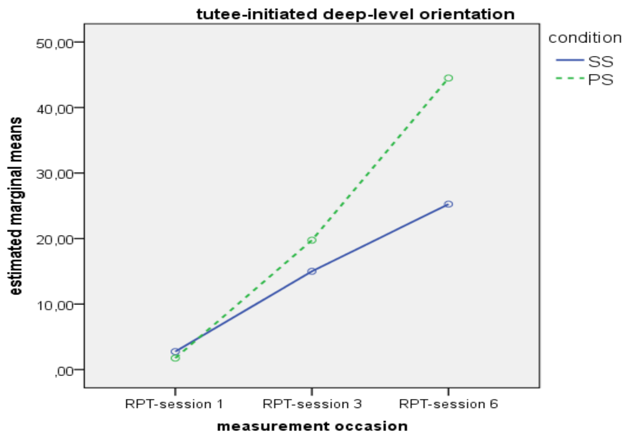

Figure 2d. Change in tutee-initiated deep-level orientation

Discussion

The present study investigated whether structuring and problematising scaffolds affect RPT-groups' metacognitive regulation behaviour differently, and in this respect aimed at identifying the most beneficial scaffold type. More specifically, the influence of both scaffolds on RPT-groups' adoption of particular regulation skills, their involvement in deep-level regulation, and tutees' initiative for regulation, was examined.

The occurrence of metacognitive regulation

The present study could not reveal significant differences between the SS-condition and the PS-condition regarding the frequency of occurrence of adopted orientation, planning, monitoring, or evaluation strategies. This result leads to questions about the role peer interactions played in enhancing RPT-groups' regulative engagement. Since joint problem solving encourages collaborative learners to adopt metacognitive regulation (Hurme et al., 2006; Manlove et al., 2007), it is possible that the RPT-setting itself was more conducive in fostering particular regulation skills than the structuring or problematising scaffolds. Additionally, it should be acknowledged that providing students with tools that support regulation, does not necessarily imply that they meaningfully adopt those tools (Puntambekar & Hübscher, 2005). Consequently, unintended use of both structuring and problematising scaffolds might have limited their unique contribution to regulating RPT-groups' problem solving. Future research, in which students are provided with explicit training in adopting metacognitive scaffolds (Choi et al., 2005; Manlove et al., 2007) and are informed about the benefits of both responding to scaffolds and adopting regulation skills (Bannert & Reimann, 2012), might optimise RPT-groups' more intentional use of provided scaffolds, potentially affecting the occurrence of particular regulation skills significantly differently in the SS-condition and PS-condition. It should further be noted that both structuring and problematising scaffolds were static in the present study. However, static scaffolds are less effective compared to adaptive scaffolds (Azevedo et al., 2005; Pea, 2004; Puntambekar & Hübscher, 2005). Consequently, the scaffolds in both the SS-condition and PS-condition might not have been sensitive enough to support RPT-groups' involvement in metacognitive regulation, preventing a differential influence on the occurrence of key regulation skills in both research conditions. Future research with dynamic scaffolds, adapting the support to group-specific learning and regulation needs, might consequently yield different results.

Deep-level metacognitive regulation

Although enhanced adoption of regulation skills is assumed to increase the probability of evolving towards deep-level regulation (Greene & Azevedo, 2007), the present study suggested that the learning experiences and peer interactions which are evoked during RPT are equally important for eliciting a deep-level regulation approach. Both the SS-condition and the PS-condition demonstrated increased regulative engagement as the RPT-intervention progressed, however, the PS-condition evolved towards a significantly higher use of deep-level regulation. In this respect, it seems plausible that problematising scaffolds' reflection-provoking nature encouraged students more to compare and elaboratively discuss or restructure their reasoning and problem solving, compared to structuring scaffolds' direct regulative instructions (Davis, 2003; Reiser, 2004). Consequently, problematising scaffolds might have evoked highly-interactive peer discussions as well as students' critical reflection on each other's regulative acts more easily, both facilitating the adoption of a deep-level regulation approach (Iiskala et al., 2011; Volet et al., 2009). It should be noted, however, that problematising scaffolds appeared mainly beneficial when students profoundly processed information to co-construct knowledge, given the significant difference between the SS-condition and the PS-condition regarding their use of deep-level (comprehension) monitoring. This finding suggests that problematising scaffolds particularly reinforce the opportunities to regulate, which are spontaneously provided during RPT, and confirms that collaborative learning environments are up to some level problematising by nature (Reiser, 2004; Pea, 2004). Tutors' permanent questioning of tutees' understanding and tutees' experienced need to control their comprehension during conceptual peer discussions, indirectly promote metacognitively-oriented exchanges aimed at deeply monitoring one's own or each other's comprehension (De Backer et al., 2015; King, 1998). The problematising scaffolds in the present study appeared to have highlighted these opportunities to monitor, fostering deep-level comprehension monitoring significantly more. In contrast, neither structuring nor problematising scaffolds appeared to be powerful enough to elicit RPT-participants' regulation behaviour which is less spontaneously applied (i.e. deep-level planning and evaluation). Future research with different types of scaffolds (e.g. prompts that are systematically included after each subtask, offering students standards for planning and evaluating profoundly; providing students with a process model outlining the problem solving stages an expert would follow; or a human agent dynamically adjusting his support to stress regulation skills and approaches that are overlooked by students – Bannert & Reimann, 2012; Manlove et al., 2007) is needed to investigate how a more balanced engagement in deep-level regulation could be supported.

Tutees' initiative for metacognitive regulation

Although both research conditions demonstrated increased tutee-initiative for regulation from the first to the sixth RPT-session, tutees in the PS-condition started to initiate RPT-groups' regulation significantly more frequently compared to their peers in the SS-condition. It seems plausible that by merely suggesting regulative acts, problematising scaffolds encouraged peer tutors more easily to operate as a coach, creating space for tutees to reflect on how to shape regulation processes and to participate in regulating collaborative learning (Hadwin et al., 2005; Rasku-Puttonen et al., 2003). On the other hand, by directly instructing students to regulate as demonstrated in structuring scaffolds, the latter might have encouraged peer tutors more easily to operate as metacognitive models, orchestrating the group's problem solving. This might have been rather hampering for tutees to initiate regulative actions. The present study, nevertheless, also raises questions about the possible influence of particular regulation skills as well as of RPT-participants' perceptions about tutors' and tutees' responsibilities on tutees' initiative for regulation (Robinson, Schofield, & Steers-Wentzell, 2005). Despite aiming to stimulate students' reflections on and initiative for all key regulation skills, problematising scaffolds only enhanced tutees' initiative for orientation (i.e. prior knowledge activation) and monitoring (i.e. of comprehension and progress) significantly more, compared to structuring scaffolds. No beneficial influence could be reported for tutee-initiated planning or evaluation. Since planning and evaluation can only be adopted at the start and upon completion of problem solving respectively (Meijer et al., 2006), the chances for reflecting on and applying both regulation skills might have been too limited for problematising scaffolds to sufficiently support tutees' initiation of RPT-groups' planning and evaluation significantly more. The relatively limited practice with both regulation skills (in both research conditions) might additionally have resulted in RPT-participants' perception of planning and evaluation being tutor-centred responsibilities (Robinson et al., 2005), whereas orientation and monitoring might have been perceived as shared responsibilities among tutor and tutees, facilitating tutees' initiative for them when being problematised.

The results further revealed that tutees' initiative for deep-level planning, monitoring, and evaluation remained rather limited in both research conditions. However, problematising scaffolds encouraged tutees significantly more to initiate deep-level orientation, compared to structuring scaffolds. The limited impact of both scaffold types on tutees' initiative for a deep-level regulation approach indicates that static scaffolds which are not adjusted to students' needs, cannot appropriately support complex regulation processes which naturally require time and intensive training to be executed by students (e.g. tutee-initiated deep-level regulation) (De Backer et al., in press a). Future research with dynamic scaffolds or a human agent offering external regulation by intensively assisting tutees in initiating deep-level regulation skills (Azevedo et al., 2005; Manlove et al., 2007), might unravel the specific benefits of structuring versus problematising scaffolds.

Recommendations for future research

Although problematising scaffolds appeared to be more beneficial for prompting RPT-groups' deep-level monitoring as well as tutees' initiative for orientation and monitoring, neither problematising nor structuring scaffolds encouraged RPT-groups into a balanced adoption of or initiative for key regulation skills and a deep-level regulation approach. By providing students with "blanket scaffolding" (i.e. identical support for all students during all phases of learning), the present study did not acknowledge RPT-groups' progressive understanding of regulating collaborative learning (Hmelo-Silver & Azevedo, 2006; Puntambekar & Hübscher, 2005). In line with the recommendations for future research discussed above, future studies should aim to assure calibrated support, based on ongoing diagnosis of RPT-groups' spontaneous and potential learning and regulation (Lajoie, 2005; Pea, 2004). Incorporating such dynamic scaffolds might evoke significantly different learning experiences when structuring versus problematising regulation skills and approaches, enhancing our insight in how to optimally scaffold RPT-groups' metacognitive regulation. Additionally, by stimulating RPT-groups into regulation which is not spontaneously implemented, the present study only assumed a production deficit without taking into account that RPT-groups' regulative competence might have been insufficient to adequately adopt the supported regulation behaviour (Bannert & Reimann, 2012; Veenman et al., 2006). Training students to apply or initiate particular regulation skills and approaches in future studies might compensate for this and optimise students' use of provided scaffolds.

It should further be noted that supporting RPT-groups to focus their attention on key regulation skills does not necessarily imply successful problem solving or productive outcomes (Reiser, 2004). Future research is needed to investigate how metacognitive scaffolds affect both individual students' and RPT-groups' learning (e.g. by including measures of domain-specific learning gains, academic achievement, cognitive reasoning, content processing), since output-related variables were not included in the present study (Azevedo & Hadwin, 2005; Berthold et al., 2007; Choi et al., 2005). Given that metacognitive scaffolds might be insufficient to promote learning, future studies on the effects of metacognitive scaffolds in combination with cognitive scaffolds could be relevant as well (Berthold et al., 2007).

Based on the current findings, it remains further questionable whether regulative support tools enhanced RPT-participants' metacognitive awareness (Manlove et al., 2007). The latter is important for transferring and optimising elicited regulation behaviour to other learning situations (Veenman et al., 2006). Although the present study revealed some significantly beneficial short-term influences of problematising scaffolds, it could not report on students' intentional use of regulation skills and approaches. Future studies should aim at investigating the relation between imposed use of regulation and raising students' metacognitive awareness in long-term research. It could furthermore be relevant to take a micro-analytical research perspective (e.g. through interaction analysis of RPT-participants' sequential conversational turns), not only identifying optimal scaffold types but also aiming to unravel during which particular learning phases scaffolds are most appropriate and when to fade the regulative support (Hadwin et al., 2005; Lajoie, 2005).

Last, a critical remark should be raised regarding the added value of structuring scaffolds in a RPT-setting. The SS-condition did not significantly outperform the PS-condition in supporting any of the examined regulation behaviour. Structuring scaffolds even appeared to hinder tutee-initiated regulation, since the latter decreased from the third to the sixth RPT-session in the SS-condition. Nevertheless, previous research revealed that non-scaffolded tutees initiate regulation more frequently, as they become more familiar with RPT (De Backer et al., in press a). Based on the results of the present study, it could be hypothesised that overstructuring a PT-setting which is inherently facilitative towards initiating metacognitive regulation is disadvantageous for tutee-initiated regulative acts. Future research with larger student populations, different subject areas, or different PT-formats (e.g. cross-age PT) is needed to examine this hypothesis.

Conclusion

The present study aimed at investigating whether structuring or problematising scaffolds are more beneficial to support RPT-groups' adoption of particular regulation skills, a deep-level regulation approach, and tutees' initiative for regulating the group's learning. The results indicated that problematising scaffolds elicited RPT-groups' deep-level monitoring, tutee-initiated (deep-level) orientation, and tutee-initiated monitoring significantly more frequently, compared to structuring scaffolds. No beneficial impact for either scaffold type could be reported for RPT-groups' adoption of key regulation skills, deep-level planning and evaluation, or tutees' initiative for the latter regulation skills.

Despite general consensus that metacognitive scaffolds can advance collaborative learners' regulation in open-ended learning environments, there is little clarity about which type of metacognitive support is most effective in eliciting particular regulation skills and approaches (Azevedo & Hadwin, 2005; Fiorella et al., 2012). The present study therefore provides interesting insights by revealing the instructional value of problematising scaffolds. This finding is especially important given the limited studies on problematising scaffolds and the dominance of structuring scaffolds in both educational research and practice (Molenaar et al., 2010; Reiser, 2004). Apart from offering innovative insights, the present study also raises additional questions (e.g. how to support a more balanced regulative involvement; how to foster tutees' initiative for deep-level regulation; are structuring scaffolds counterproductive for tutee-initiated regulation?), giving concrete input for future research. The current findings further provide educators with direct cues on how to design (i.e. integrating scaffolds which problematise learning and regulation) learning environments in order to optimise collaborative learners' adoption of and initiative for regulation.

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Appendix A Illustration of structuring and problematising scaffolds

Regulation skill addressed	Structuring scaffold	Problematising scaffold
Orientation (prior knowledge activation)	Read the following learning objectives and specify with which theoretical concepts you are (not yet) familiar.	How could you orient yourselves on this assignment?
Planning (planning in advance)	This assignment comprises of [xxx] parts. Develop an action plan to complete the assignment on time.	How could you ensure the assignment will be completed on time?
Monitoring (monitoring of progress)	You have completed the orientation task. Check whether you are still on schedule or whether your planning needs to be adjusted.	Are you still on schedule?
Monitoring (comprehension monitoring)	Check whether you all understand the theoretical concepts in the orientation task sufficiently to conduct the remaining of this assignment.	How could you check whether you all understand the theoretical concepts in the orientation task sufficiently?
Monitoring (monitoring of progress)	Check if your planning needs to be adjusted.	How could you ensure the assignment will be completed on time?
Monitoring (comprehension monitoring)	Check whether you can explain the theoretical concepts addressed in (the first part of) the assignment in your own words.	How could you check whether you all understand the theoretical concepts addressed in (the first part of) the assignment sufficiently?
Evaluation (evaluation of learning outcomes, learning process, and collaboration)	Check whether your outcomes are an answer to the instructions given. Evaluate your collaboration and reflect on possible ways to optimise future tutoring sessions.	How could you evaluate the learning outcomes and your collaboration?

7 Eliciting co-regulation and socially shared metacognitive regulation through structuring and problematising scaffolds

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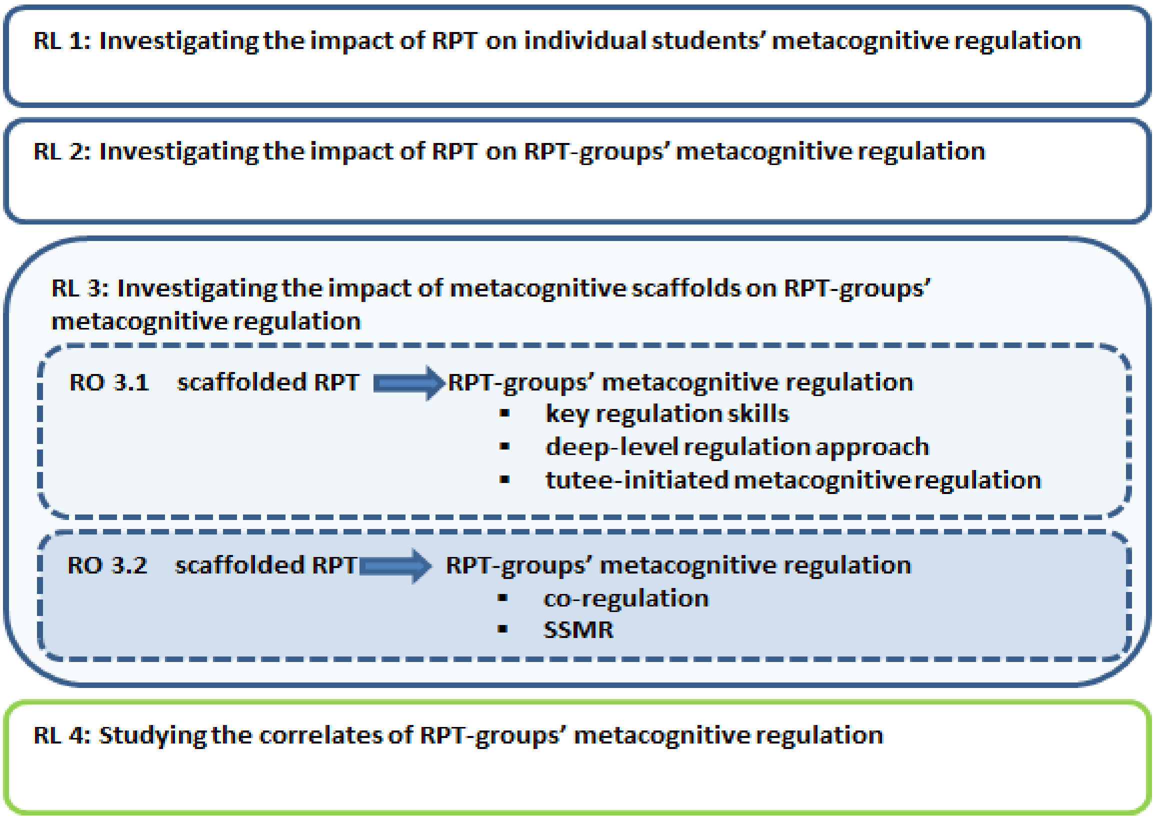

Figure 1. Chapter 7 in relation to the research lines of the dissertation

Chapter 7

Eliciting co-regulation and socially shared metacognitive regulation through structuring and problematising scaffolds

Abstract

Successfully adopting social forms of metacognitive regulation is challenging and often requires additional support. The present study examines the impact of structuring (SS) and problematising scaffolds (PS) on collaborative learners' adoption of co-regulation and socially shared metacognitive regulation (SSMR). More specifically, higher education reciprocal peer tutoring (RPT) groups are studied. A quasi-experimental design involving two experimental groups (SS-condition versus PS-condition) was adopted. The first, third, and sixth RPT-session of eight randomly selected RPT-groups (four of the SS-condition and four of the PS-condition) were videotaped and analysed (48 hrs of video recordings). Mann Whitney U tests were adopted to investigate the differential impact of structuring and problematising scaffolds on RPT-groups' adoption of tutor-prompted co-regulation, tutee-prompted co-regulation, and SSMR. Additionally, logistic regression analyses were performed to examine whether both scaffold types evoked different evolutions in RPT-groups' social forms of metacognitive regulation. The results indicated that the SS-condition significantly outperformed the PS-condition in adopting tutor-prompted co-regulation, whereas the PS-condition demonstrated significantly more tutee-prompted co-regulation and SSMR. Additionally, both conditions demonstrated a significant evolution towards increased tutee-prompted co-regulation. The SS-condition also reported a significant positive evolution in demonstrating tutor-prompted co-regulation, whereas the PS-condition showed an additional significant evolution towards SSMR.

Introduction

Successful collaborative learning requires joint coordination of problem solving and students' understanding, facilitating engagement in metacognitive regulation (Hadwin, Järvelä, & Miller, 2011; Iiskala, Vauras, Lehtinen, & Salonen, 2011). Collaborative learning groups represent unique social systems, eliciting metacognitive regulation at different levels of social interaction (Grau & Whitebread, 2012; Volet, Vauras, & Salonen, 2009b). One student can, for example, instruct others to regulate their learning, resulting in co-regulation (Rogat & Adams-Wiggins, 2014; Volet, Summers, & Thurman, 2009a). Alternatively, multiple students can interdependently regulate the group's problem solving towards shared learning goals, demonstrating socially shared metacognitive regulation (SSMR) (Iiskala et al., 2011; Järvelä, Järvenojä, Malmberg, & Hadwin, 2013). Although SSMR advances successful collaborative learning, promoting both individual students' and the group's performance (Hadwin et al., 2011; Vauras & Volet, 2013), it can be assumed that optimally executing complex regulative processes, such as jointly regulating learning, requires time and additional instructional support (Perry & Winne, 2013; Volet et al., 2009b). In this respect, metacognitive scaffolds can assist students in activating regulative acts which they would not have applied spontaneously (Azevedo & Hadwin, 2005; Bannert & Reimann, 2012; Berthold, Nückles, & Renkl, 2007) and might therefore be promising to optimise collaborative learners' SSMR. To our knowledge, empirical research on how to elicit social forms of metacognitive regulation is, however, only limitedly available (e.g. Lajoie & Lu, 2012; Molenaar, Sleegers, & van Boxtel, 2014). Prior studies on SSMR mainly focussed on conceptualising social forms of regulation and on the methodological challenges when identifying utterances of SSMR (Vauras & Volet, 2013). The present study extends previous research by examining the instructional value of structuring versus problematising scaffolds for evoking collaborative learners' adoption of co-regulation and SSMR. It more specifically investigates whether both scaffold types affect the regulation behaviour of higher education reciprocal peer tutoring groups differently. The present study not only provides innovative theoretical insights advancing the emerging research on SSMR, but also offers valuable guidelines to optimise collaborative learners' metacognitive regulation in educational practice.

Theoretical underpinnings

Social forms of metacognitive regulation

Metacognitive regulation refers to regulatory skills and strategies used by learners to control, coordinate, and regulate their personal, a collaborating peer's, or the group's learning process (Hadwin et al., 2011; Meijer, Veenman, & van Hout-Wolters, 2006). We distinguish between orienting, planning, monitoring, and evaluating as key regulation skills (De Backer, Van Keer, & Valcke, 2012). Traditionally, metacognitive regulation has been studied from an individual learner's perspective, aimed at understanding the processes individual students adopt to successfully regulate personal learning (Grau & Whitebread, 2012; Iiskala et al., 2011). However, recent literature increasingly considers the social context in which students apply metacognitive regulation, stressing that regulative acts should also be demonstrated at various levels of social interaction during collaborative problem solving, for the latter allows students to undertake joint regulative actions (Grau & Whitebread, 2012; Rogat & Adams-Wiggins, 2014; Vauras & Volet, 2013). Depending on the level of reciprocity within these joint regulation actions, (asymmetrical) co-regulation and (mutual) socially shared metacognitive regulation are discerned (Iiskala et al., 2011; Järvelä et al., 2013; Rogat & Adams-Wiggins, 2014; Volet et al., 2009b).

Metacognitive co-regulation is characterised by one student taking responsibility for regulating other students' learning (Grau & Whitebread, 2012; Hadwin et al., 2005; Rogat & Adams-Wiggins, 2014). It is demonstrated when a student instructs or prompts other collaborating students into metacognitive regulation, resulting in an unequal distribution of metacognitive engagement among collaborative learners (Järvelä et al., 2013; Perry & Winne, 2013). During metacognitive co-regulation the initiative-taking student's regulative acts are guided by intra-individual goals but directed at sustaining/correcting other students' learning and regulation (Rogat & Adams-Wiggins, 2014; Volet et al., 2009b). The role of co-regulator can shift among students across time, depending on their progressive expertise and related need to be assisted or provide assistance (Perry & Winne, 2013)[1].

A reciprocal and therefore more intensive form of social regulation is found in socially shared metacognitive regulation (SSMR) (Hadwin et al., 2011; Vauras & Volet, 2013). SSMR concerns a collectively assumed responsibility for metacognitive regulation among multiple collaborative learners (Grau & Whitebread, 2012; Iiskala et al., 2011; Järvelä et al., 2013). Although initiated by individual students' regulative acts, SSMR is characterised by subsequent involvement in metacognitive regulation of collaborating peers reciprocally operating on each other's regulative acts. It is applied when students discuss and share learning objectives, mutually monitor each other's comprehension and the group's progress, and collaboratively reflect upon their collaboration and learning outcomes (Järvelä et al., 2013; Perry & Winne, 2013; Volet et al., 2009b). SSMR is directed by a collectively negotiated understanding of group level activities and demonstrated by students mutually reacting on each other's regulative activities in a spiral-like process (i.e. one student's regulative acts are referred to in another student's regulative acts, eliciting subsequent regulative acts from a third student involved in the same regulation skill; who's regulative acts refer to both the first and the second student's contributions and in their turn elicit reciprocal regulative acts from yet another student, etc.). Optimising collaborative learners' SSMR is an important educational objective, since successful collaboration is related to students' coordinated and mutual engagement in regulating the group's learning (Iiskala et al., 2011; Volet et al., 2009a). Adopting SSMR results in better group performance, enhances students' reflection on their own and each other's mental models and problem solving strategies, and advances individual students' self-regulation and academic performance (Chan, 2012; Järvelä et al., 2013; Lajoie & Lu, 2012). Despite growing consensus on its importance, SSMR remains an empirically underexposed domain in the metacognition research.

Peer tutoring promising for adopting social forms of metacognitive regulation

Since student-activating learning environments can foster students' engagement in social forms of metacognitive regulation (Lajoie & Lu, 2012), the present study investigates the regulation behaviour of university students collaborating in a reciprocal peer tutoring setting. Peer tutoring (PT) is characterised by active academic helping and supporting between peers in small groups or student pairs (Falchikov, 2001; Topping, 2005). One peer, the tutor, takes a direct pedagogical role by creating learning opportunities through questioning, clarifying, and active scaffolding (Duran & Monereo, 2005; Roscoe & Chi, 2008). The students being cognitively challenged by this tutor, are called tutees. Reciprocal peer tutoring (RPT) in particular, is characterised by the structured exchange

[1] Although co-regulation might promote an individual student's metacognitive regulation, the present study does not conceptualise metacognitive co-regulation as a transitional process towards self-regulation, but recognises it as a specific form of regulation along the social spectrum (Volet et al., 2013).

of the tutor role among peers in the PT-pair/group (Duran & Monereo, 2005) and enables each student to experience the benefits of providing and receiving academic guidance (Falchikov, 2001; Topping, 2005).

PT invites students to take responsibility for their own and peers' learning, including metacognitively regulating the collaborative learning process. Although peer tutors tend to dominate the tutorial process by encouraging tutees into content processing and metacognitive regulation (Roscoe & Chi, 2008), their support generally evolves in order to facilitate tutee-centred learning (De Smet, Van Keer, & Valcke, 2009; Hadwin, Wozney, & Pontin, 2005). Whereas the peer tutor initially acts as a model, directing and controlling tutees' learning, he is expected to operate as tutees' coach once they gain more competence in the PT-setting (De Smet et al., 2009; Rasku-Puttonen, Eteläpelto, Arvaja, & Häkkinen, 2003). A coaching peer tutor indirectly prompts tutees' learning while tutees start to initiate tutorial discussions and regulative acts more frequently (Hadwin et al., 2005; Rasku-Puttonen et al., 2003). Although the evolution from modelling to coaching tutor support should not be equated with an evolution from tutor-prompted (initiated by the tutor) co-regulation to tutee-prompted (initiated by the tutee) co-regulation, neither with an evolution from co-regulation to SSMR, it does create a platform which allows tutees to progressively participate in the PT-group's regulation, either prompting or sharing regulative acts. It should be noted, however, that successfully regulating problem solving processes with peers in open-ended learning environments is challenging and often requires time and additional support (Azevedo & Hadwin, 2005; Molenaar et al., 2014; Perry & Winne, 2013). Since metacognitive scaffolds direct students' attention towards particular regulative acts, they might help to overcome collaborative learners' difficulties of spontaneously engaging in adequate forms of social regulation (Bannert & Reimann, 2012; Manlove, Lazonder, & de Jong, 2007).

Metacognitive scaffolds: structuring versus problematising

Introduced by Wood, Bruner, and Ross (1978), the notion of scaffolding was originally conceptualised as dynamic assistance provided by a more knowledgeable person to a novice learner, aimed at helping this learner succeed in learning activities he is unable to successfully accomplish independently and at fading the assistance as the learner's competence progresses (Pea, 2004; Puntambekar & Hübscher, 2005). Nevertheless, with computer-based learning taking an central place in educational research, scaffolding has increasingly been narrowed to instructional tools, designed to help students learn and regulate successfully (Azevedo et al., 2005; Puntambekar & Hübscher, 2005). This recent conceptualisation often abandons the intrinsically dynamic nature of scaffolding, favouring the notion of "scaffold" to describe fixed prompts and hints which operate as strategy activators (Berthold et al., 2007; Pea, 2004). Metacognitive scaffolds concern supportive aids and instructions embedded in the learning material, requiring students to carry out particular regulative acts, that they are capable of but do not always demonstrate spontaneously (Bannert & Reimann, 2012; Manlove et al., 2007). Metacognitive scaffolds support students in identifying task demands, activating prior knowledge, controlling comprehension, selecting and monitoring learning strategies, and evaluating both learning products and processes, aimed at advancing the quality and outcomes of their learning (Azevedo et al., 2005; Berthold et al., 2007; Molenaar et al., 2014). Although scaffolds have demonstrated their instructional value to enhance students' learning and understanding (e.g. Bannert & Reimann, 2012; Berthold et al., 2007; Manlove et al., 2007) little is known about which type of scaffold is most effective for eliciting collaborative learners' involvement in social forms of regulation. The present study therefore investigates whether RPT-groups' co-regulation and SSMR can be elicited through structuring or problematising scaffolds (Reiser, 2004) and whether both scaffold types affect RPT-groups' social forms of regulation differently.

Structuring scaffolds reduce the complexity of problem solving in open-ended learning environments by introducing additional structure (e.g. concrete guidelines or examples of problem-solving steps), directly demonstrating how to execute particular learning strategies or regulation skills. Structuring scaffolds simplify the learning environment, reducing students' freedom and helping them to maintain direction (Wood et al., 1978). Problematising scaffolds, on the other hand, are rather suggestive, encouraging students to take into account learning and regulation activities which they might otherwise overlook, without directly instructing them to operate as demonstrated in the scaffold (Reiser, 2004). Characterised by reflection-provoking prompts which merely highlight problem solving steps, problematising scaffolds challenge students to critically address their thinking and to optimise their learning (Molenaar et al., 2014; Wood et al., 1978). Although requiring students to reflect upon and generate productive learning and regulation strategies initially complicates the learning environment, problematising scaffolds also stimulate transfer of learning, advancing students' future problem solving (Reiser, 2004).

Aim of the present study

The present study aims at investigating whether structuring and problematising scaffolds affect RPT-groups' social forms of metacognitive regulation differently[2]. More specifically, differences in tutor-prompted co-regulation, tutee-prompted co-regulation, and SSMR are examined. The following research questions are put forward:

(1) Do structuring and problematising scaffolds elicit other forms of social metacognitive regulation in RPT-groups?
(2) Do structuring and problematising scaffolds evoke different time-bound evolutions in RPT-groups' social forms of metacognitive regulation?

Since structuring scaffolds explicitly direct students into regulation behaviour which is demonstrated in the scaffold, they are expected to encourage peer tutors more easily to operate as metacognitive models, directing tutees' regulation and orchestrating the group's problem solving. We therefore hypothesise that structuring scaffolds will elicit tutor-prompted co-regulation more frequently, as compared to problematising scaffolds (hypothesis 1a). On the other hand, by merely

[2] In the present study, "scaffold" is to be interpreted as a supportive tool provided to activate particular regulation behaviour, not as a dynamic process of offering and fading calibrated support based on ongoing diagnosis of students' progressive expertise in regulating the group's learning.

suggesting regulative acts, problematising scaffolds are expected to provoke metacognitively-oriented discussions among tutors and tutees more often than structuring scaffolds. Given that such discussions create opportunities for tutees to reflect on and contribute to regulating the group's learning (Volet et al., 2009a), we additionally hypothesise that both tutee-prompted co-regulation and SSMR will be higher when receiving problematising scaffolds, compared to being supported with structuring scaffolds (hypothesis 1b).

Given that peer tutors' support naturally evolves from modelling to coaching as tutees get familiar with the PT-setting (Rasku-Puttonen et al., 2003), we expect tutees in both research conditions to increasingly take initiative for the group's regulation, resulting in an evolution towards enhanced tutee-prompted co-regulation and decreased tutor-prompted co-regulation. However, since structuring scaffolds' directive nature is expected to facilitate tutors' regulative modelling and problematising scaffolds' reflecting-provoking nature is expected to foster tutees' regulative contributions, we hypothesise that this evolution will occur at a later stage in the SS-condition and at an earlier stage in the PS-condition (hypothesis 2a). Additionally, problematising scaffolds are expected to evoke students' reflections on their own and each other's regulative acts, stimulating their metacognitively-oriented discussions. Since the latter are positively correlated with SSMR (De Backer, Van Keer, & Valcke, 2015), we hypothesise that the PS-condition, in particular, will evolve more easily towards sharing regulation (hypothesis 2b).

Method

Participants and setting

The study was conducted in a naturalistic university setting. Fifty-eight first-year Educational Sciences students who already obtained a Professional Bachelor degree (5.3% males and 94.7% females) participated in a semester-long RPT-intervention. Students were randomly assigned to ten RPT-groups. The RPT-intervention was a formal component of students' 5-credit course "Instructional Sciences" and focussed on deepening students' understanding of learning content that was previously addressed in theoretical lectures.

Design

A quasi-experimental design was adopted, involving two experimental conditions. Five randomly selected RPT-groups were assigned to a structuring scaffold (SS) condition, whereas the remaining five RPT-groups were assigned to a problematising (PS) scaffold condition. All aspects of the RPT-intervention were identical in both research conditions, except for the provided scaffolds. The SS-condition was supported through direct guidelines, instructing students to apply particular regulation skills, whereas the PS-condition was given reflection-provoking prompts encouraging students to reflect upon the execution of particular regulation skills. Both types of scaffolds were embedded in the learning material (i.e. RPT-assignments), addressed identical regulation skills, and were provided at the same time during the problem solving process. Each RPT-assignment furthermore integrated the same scaffolds throughout the complete intervention. Appendix A provides an overview of the scaffolds presented in both conditions.

RPT-intervention

The RPT-intervention consisted of eight successive face-to-face sessions (including a training session) of 2 hours each, in which students tutored each other in small and stable groups of six. The tutor role was randomly appointed to students by a university staff member and interchanged at each session within each RPT-group. During each RPT-session, the tutor was primarily responsible for managing the interactions and stimulating collaborative learning, whereas tutees were occupied with solving the group assignment. As a manipulation check, all RPT-groups were observed weekly, to control whether tutors and tutees enacted their roles adequately and whether RPT-groups adopted the scaffolds as intended.

Assignments

During each RPT-session, students worked on authentic group assignments, linked to themes in the course “Instructional Sciences” (De Backer et al., 2012). The assignments were presented as open-ended tasks requiring students’ collaboration and high levels of cognitive processing. Each assignment consisted of an outline of learning objectives; a subtask to get familiar with theme-specific terminology; and a subtask to apply theory to real-life cases. Despite differences in the central topic, all assignments addressed comparable learning experiences during each RPT-session.

Training

Students participated in a compulsory tutor training, one week before the onset of the RPT-intervention. During this training, they were informed about the multidimensional responsibilities of the peer tutor and were taught a mix of generic tutoring skills. The focus was more specifically on establishing a safe learning climate, managing and stimulating interactions, asking differentiated questions, giving constructive feedback, and providing comprehensive explanations (Chi, Siler, Jeong, Yamauchi, & Hausmann, 2001; Falchikov, 2001; King, 1998; Roscoe & Chi, 2008; Webb, 2009). The tutor training was summarised in a manual provided to each tutor.

Tutor guide

To prepare themselves, peer tutors received a session-specific “tutor guide” one week in advance. This guide consisted of a 10-page manual and offered additional information about the theory to focus upon in the RPT-session, for the PT-literature stresses the necessity of a difference in peer tutors' and tutees' domain-specific knowledge (Falchikov, 2001; Topping, 2005). Additionally, the tutor guide inspired students to tackle the problem solving process stepwise, by offering examples to explore task demands, develop actions plans, verify whether task requirements are met, and reflect on the RPT-session. These problem solving steps were depicted in a schematic overview, provided to each tutor (De Backer et al., 2012).

Interim support

To provide student support, interim supervision sessions (taking two hours) and two-weekly feedback sessions (each taking 30 minutes) were organised. Halfway through the RPT-intervention, compulsory supervision sessions were organised for all students. These were set up in small groups of twelve students (recruited from two randomly selected RPT-groups) and directed by a staff member, who encouraged students to reflect on their behaviour as tutor and tutee. Additionally, the staff member provided group-specific feedback every two weeks, focusing on group dynamics, peer collaboration, equal contribution of tutees, and students' tutoring approach. The feedback resulted in group reflections and action plans to optimise peer collaboration.

Data collection

The first, third, and sixth RPT-session (at the starting, intermediate, and closing phase of the RPT-intervention, respectively) of eight randomly selected RPT-groups (i.e. four groups/24 students from the SS-condition and four groups/24 students from the PS-condition) were videotaped (i.e. 48 hours of video recordings). The video data provided real-time information about tutors' and tutees' learning activities, including their metacognitive regulation behaviour.

Coding instrument

Utterances of metacognitive regulation were identified using the RPT_MCR instrument (i.e. RPT-groups' metacognitive regulation – De Backer, Van Keer, Moerkerke, & Valcke, in press), representing a multi-layered model of metacognitive regulation in collaborative settings. Orientation, planning, monitoring, and evaluation are adopted as the main coding categories and specified with sub-coding categories (i.e. task analysis, activating prior knowledge, task perceptions, planning in advance, interim planning, monitoring of comprehension, monitoring of progress, monitoring of collaboration, evaluation of learning outcomes, evaluation of the learning process, and evaluation of collaboration). Additionally, a dimension on the social forms of regulation is included, based on the regulative agents involved in metacognitive utterances and the reciprocity of their regulative actions. Tutor-prompted co-regulation, tutee-prompted-co-regulation, and SSMR are distinguished as coding categories. The present study conceptualises co-regulation as instructions from either the tutor

(tutor-prompted) or a tutee (tutee-prompted) towards another student or the RPT-group to engage in metacognitive regulation. SSMR is conceptualised as interdependent regulative actions at the group level, demonstrated by a joint and reciprocal involvement of multiple (i.e. at least three) students in a particular regulation skill or strategy. All coding categories in the instrument are developed from the literature on metacognitive regulation, as presented in the theoretical part of this article.

Coding strategy

The coding procedure followed subsequent phases and was exclusively focussed on students' verbalised interaction. First, peer discussions from each RPT-session were divided into broad segments by means of episode coding, according to changes in the topic of discussion (Chi et al., 2001). An episode is conceptualised as a rather large segment (including multiple conversational turns) of the overall interaction that was centred around one particular topic of discussion. After segmentation, each episode was labelled as either metacognitive regulation, task execution (i.e. problem solving or knowledge transmission), or off-task behaviour. Second, metacognitive episodes were reanalysed for more detailed statement coding at the turn level (Roscoe & Chi, 2008). A statement (representing a single conversational turn) refers to a single thematically consistent verbalisation of a single metacognitive action by a single student. Each metacognitive statement was given a code from the RPT_MCR instrument, indicating the general regulation skill it addressed and the concretised regulation strategy it represented. Third, metacognitive statements were analysed further to check the regulative agents involved and the reciprocity of reactions following a metacognitive statement, in order to identify social forms of regulation (see Appendix B). Metacognitive statements which were intended to instruct one or more peers to regulate, were segmented as tutor-prompted or tutee-prompted co-regulation (depending on tutors' respectively tutees' initiative). When no reaction was given to such a regulative instruction, the co-regulation unit merely consisted of the initiative-taking student's metacognitive statement. When regulative acts followed regulative instructions, the metacognitive statements of the students involved represented an interactive co-regulation unit (i.e. action-reaction exchange at the dyadic level). On the other hand, units of SSMR represented sequences of reciprocal conversational turns (i.e. a sequence of mutual action-reaction exchanges among three or more RPT-participants, referring to one common regulative strategy), which were labelled after interaction coding (Roscoe & Chi, 2008). Typically, a SSMR-unit proceeded through different (i.e. at least three) RPT-participants' metacognitive statements. The start of a SSMR-unit consisted of the RPT-participant's metacognitive statement which triggered other students to join in the regulative action, whereas the end of the unit was marked by the last metacognitive statement directed at mutual engagement in a particular metacognitive regulation skill. Both the start and the end of an interactive SSMR-unit could be traced back after students' reciprocal statements as a whole indicated a socially shared metacognitive focus (Iiskala et al., 2011).

Coding of the video data was accomplished by two trained coders. They were blind to both the scaffold conditions and RPT-sessions. The coders double-coded 20% of the recorded sessions to determine interrater reliability. Cohen's kappa indicates high interrater reliability for the coding of 'metacognitive regulation' (κ = .87), and good agreement beyond chance for coding the social forms of regulation (κ=.79).

Data analysis

After coding the video data, the frequency of occurrence of metacognitive regulation skills and the different forms of social metacognitive regulation were calculated for each RPT-group and RPT-session. These frequencies were used for analysis purposes. In total, 20698 metacognitive statements were distinguished, of which 5505 were prompted by a co-regulator and 2351 were socially shared. To investigate whether structuring and problematising scaffolds generated a differential impact on RPT-groups' adoption of tutor-prompted co-regulation, tutee-prompted co-regulation, and SSMR (research question 1), Mann-Whitney U tests were run, comparing the median of each form of social metacognitive regulation between the research conditions on each measurement occasion (i.e. first, third, and sixth RPT-session) [3]. The effect size estimate *r* is reported as a measure of the effect size of significant differences between research conditions, with benchmarks r=.10 as a small effect; r=.30 as medium, and r=.50 as a large effect. To examine whether structuring and problematising scaffolds evoke other evolutions in RPT-groups adopting social forms of metacognitive regulation (research question 2), binary logistic regression analyses are conducted for each research condition separately. The occurrence (i.e. occurrence versus non-occurrence) of respectively tutor-prompted co-regulation, tutee-prompted co-regulation, and SSMR served as binary dependent variable. Measurement occasion served as independent variable and comprised of three categories (i.e. the first, third, and sixth RPT-session). The third RPT-session was adopted as reference category in each model. To analyse the strength of significant differences over time, odds ratios were calculated. The significance level was set at .05 for all analyses.

Results

Descriptives on RPT-groups' metacognitive regulation

Table 1 reveals that RPT-groups' engagement in SSMR gradually grows from the first to the sixth RPT-session but that it remains limited compared to RPT-groups' co-regulation, both in the SS-condition and the PS-condition. Both research conditions further demonstrate a comparable adoption of co-regulation (both tutor-prompted and tutee-prompted) and SSMR during the first RPT-session, but their involvement in tutor- versus tutee-prompted co-regulation evolves differently from

[3] Since the variable 'tutee-prompted co-regulation' was not normally distributed but showed a skewness to the left, we opted for non-parametric testing by means of Mann-Whitney U tests. Taking into account the research hypotheses formulated above, one-sided testing was adopted for all conducted Mann-Whitney U tests.

the third RPT-session onwards. Whereas RPT-groups in the SS-condition mainly show tutor-prompted co-regulation, RPT-groups in the PS-condition engage more frequently in tutee-prompted co-regulation, both at RPT-session 3 and 6 (see Table 1).

Impact of structuring and problematising scaffolds on RPT-groups' involvement in social forms of regulation

During the first RPT-session, no significant difference (*U*=5.00, *p*=.243) is revealed for RPT-groups' tutor-prompted co-regulation in the SS-condition (*Mdn*=103.50), compared to the PS-condition (*Mdn*=83.50). In contrast, both at the third and the sixth RPT-session, the SS-condition (*Mdn*=170.50 and *Mdn*=204.50, respectively) significantly outperforms the PS-condition (*Mdn*=98.50 and *Mdn*=130.50, respectively) in tutor-prompted co-regulation (*U*=0.01, *p*=.014, *r*=0.81 and *U*=0.01, *p*=.015, *r*= 0.82, respectively).

Regarding RPT-groups' tutee-prompted co-regulation, the results indicate that the SS-condition (*Mdn*=51.00) is not significantly different from the PS-condition (*Mdn*=51.50) at RPT-session 1 (*U*=7.50, *p*=.443). However, both at the third and the sixth RPT-session, the PS-condition (*Mdn*=130.00 and *Mdn*=190.50, respectively) engages significantly more in tutee-prompted co-regulation (*U*=2.00, *p*=.042, *r*=0.61 and *U*=0.01, *p*=.015, *r*= 0.82, respectively), compared to the SS-condition (*Mdn*=71.00 and *Mdn*=93.50, respectively).

The results further reveal that RPT-groups' SSMR is not significantly different in the SS-condition (*Mdn*=25.50 and *Mdn*=28.50, respectively) compared to the PS-condition (*Mdn*=21.50 and *Mdn*=34.00, respectively), at the first (*U*=5.50, *p*=.243) and the third RPT-session (*U*=3.00, *p*=.100). However, the PS-condition (*Mdn*=44.00) significantly outperforms the SS-condition (*Mdn*=33.50) in socially sharing metacognitive regulation (*U*=1.50, *p*=.029) at RPT-session 6.

Impact of structuring and problematising scaffolds on RPT-groups' evolving adoption of social forms of regulation

Logistic regression analyses confirm the abovementioned differences between both research conditions from the third RPT-session onwards, revealing different evolution patterns in the adoption of social forms of metacognitive regulation (see Table 2). RPT-groups in the SS-condition significantly increase their adoption of co-regulation, both tutor-prompted ($\chi^2(2)$=186.39, *p*<.001) and tutee-prompted ($\chi^2(2)$=94.89, *p*<.001), as the RPT-intervention progresses. Compared to the third RPT-session, the odds of tutor-prompted co-regulation are 1.61 times lower at the first RPT-session, whereas they are 1.17 times higher at RPT-session 6. Similarly, the odds of tutee-prompted co-regulation are 1.37 times lower at the starting compared to the third RPT-session, whereas they are 1.33 times higher at the sixth RPT-session. No significant differences between the three measurement occasions are reported for RPT-groups' involvement in SSMR ($\chi^2(2)$=2.85, *p*=.241).

Table 1. *Occurrence of social forms of metacognitive regulation during the three RPT-sessions in both research conditions (frequencies and percentages)*

Metacognitive regulation	**RPT-session 1**				**RPT-session 3**				**RPT-session 6**			
	SS		**PS**		**SS**		**PS**		**SS**		**PS**	
	freq.	*%*	*freq.*	*%*	*freq.*	*%*	*freq.*	*%*	*freq.*	*%*	*freq.*	*%*
Tutor-prompted co-regulation	418	13.85	367	13.62	657	20.22	404	12.34	822	20.69	492	10.96
Tutee-prompted co-regulation	201	6.66	226	8.39	287	8.83	478	14.60	391	9.84	762	16.98
SSMR	100	3.31	87	3.23	116	3.57	134	4.09	136	3.42	178	3.97

Note: SS= structuring scaffold; PS= problematising scaffold; SSMR= socially shared metacognitive regulation

Table 2. *Logistic regression estimates for RPT-groups' evolving adoption of co-regulation and SSMR in both research conditions*

Dependent variable	**Independent variable**	***Estimate***	***SE***	***Wald***	***df***	***p***	***OR***	***OR^{-1}***	***95% CI***
SS-condition									
Tutor-prompted co-regulation	RPT-session 1	-0.48	0.50	91.57	1	<.001	0.62	1.61	(-0.80; 0.28)
	RPT-session 3	reference category							
	RPT-session 6	0.16	0.04	12.80	1	<.001	1.17		(0.04; 0.13)
Tutee-prompted co-regulation	RPT-session 1	-0.31	0.07	21.61	1	<.001	0.73	1.37	(-0.25; -0.10)
	RPT-session 3	reference category							
	RPT-session 6	0.29	0.06	25.19	1	<.001	1.33		(0.10; 0.22)
SSMR	RPT-session 1	0.04	0.06	0.54	1	.461	1.05		(-0.04; 0.09)
	RPT-session 3	reference category							
	RPT-session 6	-0.06	0.05	0.88	1	.347	0.95	1.05	(-0.09; 0.02)
PS-condition									
Tutor-prompted co-regulation	RPT-session 1	0.22	0.06	15.37	1	<.001	1.24		(0.05; 0.19)
	RPT-session 3	reference category							
	RPT-session 6	-0.03	0.05	0.25	1	.615	0.97	1.03	(-0.07; 0.04)
Tutee-prompted-co-regulation	RPT-session 1	-0.73	0.06	142.91	1	<.001	0.48	2.07	(-0.47; -0.34)
	RPT-session 3	reference category							
	RPT-session 6	0.35	0.05	55.72	1	<.001	1.42		(0.14; 0.25)
SSMR	RPT-session 1	-0.16	0.06	7.84	1	.005	0.85	1.18	(-0.15; -0.02)
	RPT-session 3	reference category							
	RPT-session 6	-0.70	0.04	2.79	1	.095	0.93	1.07	(-0.43; -0.34)

Note: SS=structuring scaffold; PS= problematising scaffold; SSMR= socially shared metacognitive regulation; OR= odds ratio; OR^{-1}= inverse odds ratio; CI= confidence interval

In contrast, RPT-groups in the PS-condition significantly evolve towards more SSMR ($\chi^2(2)=15.16$, $p<.001$), more specifically from the first to the third RPT-session. Compared to the first RPT-session, the odds of SSMR are 1.18 times higher at RPT-session 3. No significant differences are revealed from the third to the sixth RPT-session ($p=.095$). Additionally, the PS-condition demonstrates significantly enhanced tutee-prompted co-regulation ($\chi^2(2)=15.16$, $p<.001$). Compared to the third RPT-session, the odds are 2.07 times lower at RPT-session 1, whereas they are 1.41 times higher at RPT-session 6. The PS-condition further demonstrates a significant decrease in tutor-prompted co-regulation ($\chi^2(2)=24.00$, $p<.001$) from the first to the third RPT-session. Compared to first RPT-session, the odds are 1.24 times lower at RPT-session 3. No significant differences are revealed when comparing the third with the sixth RPT-session ($p=.615$).

Discussion

The present study examined whether structuring and problematising scaffolds affect RPT-groups' engagement in social forms of metacognitive regulation differently. More specifically, the influence of both scaffolds on RPT-groups' adoption of and evolution in tutor-prompted co-regulation, tutee-prompted co-regulation, and SSMR was investigated.

Eliciting co-regulation

The results confirmed the hypothesis that structuring scaffolds promote RPT-groups' engagement in tutor-prompted co-regulation, whereas problematising scaffolds stimulate tutee-prompted co-regulation. The SS-condition not only demonstrated significantly more tutor-prompted co-regulation than the PS-condition, the former also evolved towards significantly increased tutor-prompted co-regulation throughout the RPT-intervention (an evolution which was not discerned in the PS-condition). On the other hand, problematising scaffolds elicited significantly more tutee-prompted co-regulation than structuring scaffolds and evoked a gradually growing adoption of tutee-prompted co-regulation from the first to the sixth RPT-session. These findings suggest that by urging students to regulate as demonstrated in the scaffold, structuring scaffolds' more directive nature might especially have appealed to tutors' pedagogical responsibility towards the RPT-group, encouraging them to model regulation and to direct the group's learning (Hadwin et al., 2005; Rasku-Putonen et al., 2003). On the other hand, problematising scaffolds appeared to have promoted tutors' coaching support, creating a platform for tutees to reflect upon and participate in regulating the group's problem solving, eliciting more tutee-prompted co-regulation. In this respect, students' perceptions of the tutor and tutee role should be acknowledged as well (Robinson, Schofield, & Steers-Wentzell, 2005). It seems plausible that structuring scaffolds reinforced students' perception of the tutor being primarily responsible for managing and regulating the group's learning, whereas problematising scaffolds might have confirmed students' perception of tutees being expected to gradually take ownership of regulating one's own and each other's learning. Future research by means of stimulated recall interviews with RPT-participants could detect students' perceptions on tutor versus tutee responsibilities and unravel the interplay between these perceptions, the changes in tutors' support, and how this affects students' scaffolded regulative acts.

It should further be noted that increased tutee-prompted co-regulation does not necessarily imply a decrease in tutor-prompted co-regulation, as was hypothesised in the present study. Although the PS-condition's evolution towards tutee-prompted co-regulation was related to tutors' decreasing co-regulative acts, the results also revealed that RPT-groups in the SS-condition simultaneously increased their engagement in both tutor-prompted and tutee-prompted co-regulation. In other words, the particular learning experiences evoked by the different scaffold types appeared not to exclusively affect changes in tutors' support. The current findings rather raise questions about the role of peer interactions in enhancing tutee-prompted co-regulation. Since joint problem solving encourages students to adopt metacognitive regulation (Hurme et al., 2006; Manlove et al., 2007) and increased regulative practice facilitates students' (i.e. tutees') initiative for regulation (De Backer et al., in press; Hadwin et al., 2005), it is possible that the RPT-setting in itself was inherently conductive in fostering tutee-prompted co-regulation. In this respect, future research investigating the natural changes in tutor support in combination with RPT-groups' spontaneous adoption of social forms of regulation is needed, to fully understand the dynamics between the evolving roles of tutor and tutee and their initiative for co-regulating RPT-groups' learning.

Taking into account that problematising scaffolds appeared to be most beneficial for supporting tutee-initiated co-regulation of peers' or the group's learning, educators are recommended to invest time and effort in designing collaborative learning environments in which these scaffolds are integrated. Fostering tutees' initiative for regulating collaborative problem solving is important to optimise tutees' involvement in group-related processes, which can in its turn deepen their learning experience and advance learning outcomes (Hadwin et al., 2005; Rogat & Adams-Wiggins, 2014).

Eliciting SSMR

The results revealed that problematising scaffolds are more beneficial for supporting RPT-groups' engagement in SSMR, compared to structuring scaffolds. The PS-condition significantly outperformed the SS-condition in demonstrating SSMR and additionally evolved towards significantly enhanced adoption of SSMR as the RPT-intervention progressed (an evolution which was not discerned for the SS-condition). These findings suggest that challenging students to critically address their regulation stimulates their regulative discussions and reflections, encouraging them to jointly regulate the group's learning at the interpersonal level (Iiskala et al., 2011; Molenaar et al., 2014; Volet et al., 2009a). On the other hand, since directive group members (e.g. an instructive peer tutor increasingly co-regulating RPT-groups' problem solving in the SS-condition) are rather hampering for collaborative learners' engagement in SSMR (Rogat & Adams-Wiggins, 2014), structuring scaffolds might even have been counterproductive for eliciting SSMR. It should nevertheless be noted that significant differences in SSMR between the SS-condition and the PS-condition were only revealed for the sixth

RPT-session. In other words, for most of the RPT-intervention, both scaffold types did not generate a differential impact on RPT-groups' SSMR. It could be assumed that RPT-participants' (regulative) discussions during collective problem solving might have operated as natural catalysts, spontaneously prompting SSMR (Iiskala et al., 2011; Järvelä et al., 2013). This might explain why RPT-groups' adoption of SSMR grew (albeit not always significantly) in both research conditions, as well as why both scaffold types failed to establish a beneficial impact at the first and third RPT-session. Additionally, it should be acknowledged that providing students with tools supporting regulation, does not necessarily imply that they adopt those tools optimally (Puntambekar & Hübscher, 2005). Consequently, unintended use of both structuring and problematising scaffolds might have limited their unique contribution to RPT-participants' shared regulative acts. Future research, in which students are informed about the benefits of metacognitive scaffolds and socially sharing their regulation (Bannert & Reimann, 2012; Manlove et al., 2007), might optimise RPT-groups' more intentional use of structuring versus problematising scaffolds, potentially affecting the occurrence of SSMR in both research conditions differently from the start of the RPT-intervention onwards.

The finding that problematising scaffolds only appeared to have an added value for prompting RPT-groups' SSMR from the sixth RPT-session onwards, might also imply that collaborative learners need time and practice to develop or optimise the skills required for sharing and reciprocally contributing to regulating the group's learning (Perry & Winne, 2013; Volet et al., 2009b). Metacognitive scaffolds (either structuring or problematising) cannot advance RPT-groups' SSMR as long as students' competence to engage in SSMR is insufficient (Veenman et al., 2006). Further, students in the present study were provided with static scaffolds, while it can be assumed that adequately eliciting complex regulation processes such as SSMR requires intensive and calibrated support (Pea, 2004; Puntambekar & Hübscher, 2005). Future research with dynamic scaffolds adjusted to collaborative learners' progressive expertise in socially regulating collaborative problem solving, or a human agent offering external regulation by intensively assisting collaborative learners in performing SSMR (Azevedo et al., 2005; Manlove et al., 2007), might unravel the specific benefits of structuring versus problematising scaffolds earlier in the RPT-intervention.

Given that the PS-condition demonstrated significantly more SSMR, we recommend educators to integrate problematising scaffolds in students' learning materials when aiming at stimulating collaborative learners' SSMR. The latter is a valuable educational objective since mutually contributing to joint regulation activities advances productive collaboration, as well as individual group members' learning and self-regulation skills (Chan, 2012; Iiskala et al., 2011; Lajoie & Lu, 2012). This is especially important for higher education students, who are expected to manage and regulate their learning independently (Bruinsma, 2004; Järvela et al., 2013).

Limitations of the present study and recommendations for future research

Although the present study adds innovative insights to the emerging research on social forms of metacognitive regulation, its limitations should also be acknowledged. First, since the present study included only two experimental conditions, it remains unclear to what extent peers' interactions during collaborative learning operate as catalysts, naturally engaging students into social forms of metacognitive regulation (Hurme et al., 2006; Iiskala et al., 2011). Future research by means of a quasi-experimental design with a control group (not receiving any kind of regulative support through scaffolds), could enhance our understanding in this respect. Comparing the influence of structuring and problematising scaffolds with the regulation behaviour of non-scaffolded RPT-groups would also allow to examine whether and how metacognitive scaffolds are more conducive for involving RPT-groups in social forms of metacognitive regulation, compared to the collaborative learning process itself.

Second, by providing all RPT-groups with identical support during all phases of learning, the present study did not acknowledge RPT-participants' progressive understanding of regulating collaborative learning at the interpersonal level (Azevedo & Hadwin, 2005; Puntambekar & Hübscher, 2005). Future research should therefore aim to assure calibrated support, based on ongoing diagnosis of RPT-groups' spontaneous versus potential regulative acts (Lajoie, 2005; Pea, 2004). Incorporating dynamic scaffolds might maximise the difference in learning experiences evoked through structuring versus problematising scaffolds, and consequently enhance our insight in how to optimally support RPT-groups' (tutee-prompted) co-regulation and SSMR. It should further be noted that the scaffolds in the present study only addressed key regulation skills (i.e. supporting students to orient, plan, monitor, or evaluate their learning), without taking into account the individual versus social level on which these regulation skills can be demonstrated. Incorporating scaffolds that explicitly encourage students to adopt particular forms of social metacognitive regulation (i.e. structuring versus problematising the social level on which to adopt key regulation skills) might, however, be more appropriate for eliciting co-regulation and SSMR. Additionally, by stimulating RPT-groups into social forms of regulation which they might not have demonstrated spontaneously, the present study only assumed a production deficit. It did, however, not take into account that RPT-groups' regulative competence might have been insufficient to adequately adopt the supported regulation behaviour (Bannert & Reimann, 2012; Veenman et al., 2006). Training students to co-regulate each other's learning or to mutually engage in joint regulative acts in future studies, might compensate for this and optimise students' use of provided scaffolds.

Third, it should be acknowledged that supporting RPT-groups to regulate their learning does not necessarily imply successful problem solving or productive learning outcomes (Reiser, 2004). Future research is needed to investigate how metacognitive scaffolds influence both individual students' and RPT-groups' learning (e.g. by including measures of domain-specific learning gains, academic achievement, cognitive reasoning, content processing, etc.), given that output-related variables were not included in the present study (Azevedo & Hadwin, 2005; Berthold et al., 2007; Rogat & Adams-Wiggins, 2014). Since collaborative learners' social position in the group also determines both their opportunities to participate in joint regulative acts and their learning outcomes (e.g. students who are marginal to the group engage limitedly in social forms of regulation, which disadvantages their learning – Rogat & Adams-Wiggins, 2014), it could additionally be interesting to visualise the collaborative learning and regulation processes which emerge after being supported with structuring versus problematising scaffolds. Visualising RPT-participants' social interactions, for example by means of social network analysis (Hurme et al., 2006), could grasp the dynamics through which scaffolded co-regulation and SSMR are elicited and shaped. Additionally, it could clarify in more detail how (scaffolding) social forms of metacognitive regulation affects the quality of RPT-groups' problem solving as well as individual RPT-participants' learning outcomes (Hurme et al., 2006; Rogat & Adams-Wiggins, 2014).

Last, it remains unclear whether the regulative support tools provided in the present study enhanced RPT-participants' metacognitive awareness (Manlove et al., 2007). The latter is important for transferring and optimising elicited regulation behaviour to other learning situations (Veenman et al., 2006). Although the current findings revealed some significantly beneficial short term influences of particularly problematising scaffolds, it could not report on students' intentional adoption of co-regulation or SSMR. Future studies should aim to investigate whether and how metacognitive scaffolds can raise students' metacognitive awareness in long-term research.

Conclusion

The present study aimed to investigate whether structuring or problematising scaffolds are more beneficial for supporting RPT-groups' engagement in tutor-prompted co-regulation, tutee-prompted co-regulation, and SSMR. The results indicated that structuring scaffolds elicited RPT-groups' adoption of tutor-prompted co-regulation significantly more, whereas problematising scaffolds stimulated RPT-groups' involvement in both tutee-prompted co-regulation and SSMR significantly more. These findings provide innovative insights directly advancing the literature on social forms of metacognitive regulation and the emerging research on SSMR in particular. Despite growing agreement about the importance of SSMR, empirical evidence on how to promote collaborative learners' shared regulative acts is scarce (Molenaar et al., 2014; Vauras & Volet, 2013). The results of the present study highlight the added value of problematising scaffolds in this respect. This finding is particularly important given the dominance of structuring scaffolds in educational research and practice (Reiser, 2004). The current findings further provide educators with concrete cues on how to design collaborative learning environments (i.e. integrate scaffolds that problematise problem solving steps and metacognitive regulation skills), which can foster students' engagement in social forms of metacognitive regulation (i.e. tutee-prompted co-regulation and SSMR).

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Appendix A Illustration of structuring and problematising scaffolds

Regulation skill addressed	Structuring scaffold	Problematising scaffold
Orientation (prior knowledge activation)	Read the following learning objectives and specify which theoretical concepts you are (not yet) familiar with.	How could you orient yourselves on this assignment?
Planning (planning in advance)	This assignment comprises of [xxx] parts. Develop an action plan to complete the assignment on time.	How could you ensure the assignment will be completed on time?
Monitoring (monitoring of progress)	You have completed the orientation task. Check whether you are still on schedule or whether your planning needs to be adjusted.	Are you still on schedule?
Monitoring (comprehension monitoring)	Check whether you all understand the theoretical concepts in the orientation task sufficiently to conduct the remaining of this assignment.	How could you check whether you all understand the theoretical concepts in the orientation task sufficiently?
Monitoring (monitoring of progress)	Check whether your planning needs to be adjusted.	How could you ensure the assignment will be completed on time?
Monitoring (comprehension monitoring)	Check whether you can explain the theoretical concepts addressed in (the first part of) the assignment in your own words.	How could you check whether you all understand the theoretical concepts addressed in (the first part of) the assignment sufficiently?
Evaluation (evaluation of learning outcomes, learning process, and collaboration)	Check whether your outcomes are an answer to the instructions given. Evaluate your collaboration and reflect on possible ways to optimise future tutoring sessions.	How could you evaluate the learning outcomes and your collaboration?

Appendix B Illustrations of social forms of metacognitive regulation

Excerpt from RPT-discussion	Social form of regulation
T: “Tina, can you remember the characteristics of constructivism?”	
t1: “Active learners and coaching teachers.”	
T: “Okay. And which type of learning is desired?”	Orientation (prior knowledge activation)
t1: “Discovery learning?”	
T: “Indeed! What ”	
t2: “Tutor, sorry to interrupt, but apart from discovery learning there was another type... I cannot remember the name.”	
T: “Experiential learning?”	
t2: “Yes! And was the constructivist teacher called facilitator?”	
T: “Indeed!”	
t3: “Okay, only 30 minutes left. Maybe it is wise to start the last subtask?”	Monitoring (of progress)
t1: “One more question. Wasn’t the teacher guiding practitioner? What is the difference with facilitator?”	
T: “Someone who can help?”	
t4: “Guiding practitioner is directive compared to the facilitator, not so? At the start the teacher guides, but he facilitates as students are more experienced in active learning, right?”	
t2: “Hmm...Aren’t both synonyms? Taken from different authors but basically implying the same, no? Teachers design learning environments to foster discovery learning, no?”	
t3: “Sounds good! And learners need some kind of support, so teachers guide and model… being a guiding practitioner, right?”	
t4: “Bob, you have your handbook. May you check whether our interpretation is correct?”	Monitoring (of comprehension)
T: “I think that’s wise because modelling and coaching are two different styles according to me. What’s in the handbook?”	
t2: *[reads information from the handbook out loud]*	
t1: “Okay, basically a constructivist teacher promotes active student learning and his actions are labelled as both facilitating and guiding practitioner.”	
t4: “Or acting as a coach, not so?”	
t2: “I think. But modelling is different.”	
t3: “Okay, I wrote that in our report. Shall I read it so that you can check the correctness? (...)	Monitoring (of progress)

Note: T= tutor; t=tutee

Tutor-prompted co-regulation

Tutee-prompted co-regulation

SSMR

8 Metacognitive regulation during reciprocal peer tutoring: Examining its relationship with students' content processing and transactive discussions

This chapter is based on:

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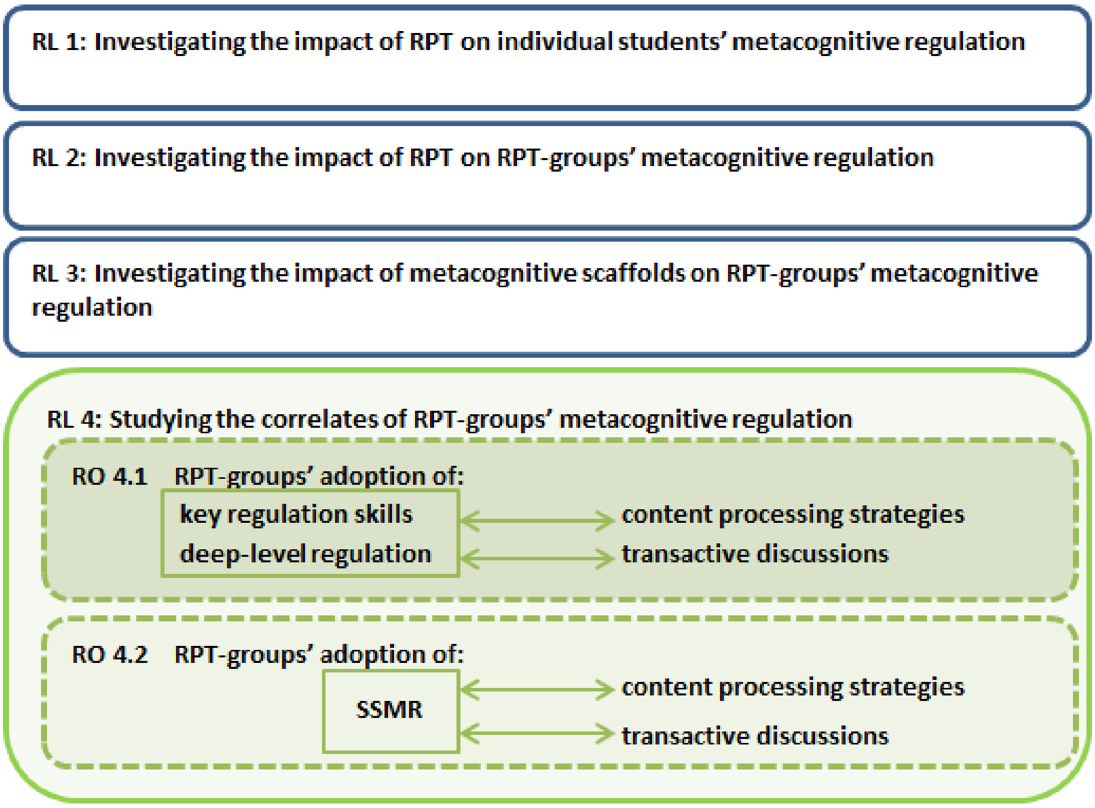

Figure 1. Chapter 8 in relation to the research lines of the dissertation

Chapter 8
Metacognitive regulation during reciprocal peer tutoring: Examining its relationship with students' content processing and transactive discussions

Abstract

Process-oriented studies on how collaborative learners' ongoing interaction is related to their adoption of metacognitive regulation are limited. The present study investigates how collaborative learners' engagement in particular regulation skills and deep-level regulation is related to their content processing strategies and the level of transactivity in their peer discussions. The study is conducted in a naturalistic reciprocal peer tutoring (RPT) setting in higher education. Sessions of five randomly selected RPT-groups participating in a semester-long RPT-intervention were videotaped (70hrs). Binary logistic regressions were performed to examine the abovementioned relationships. Results reveal a positive but differential correlation of content processing strategies and specific regulation skills, as well as a significant association of higher-order content processing and deep-level regulation. Transactive discussions are significantly correlated to students' orientation and monitoring only. Remarkably, deep-level regulation is significantly and comparably associated with both representational and operational cognitively-oriented and metacognitively-oriented transactive discussions.

Introduction

New perspectives on metacognition stress the value of collaborative learning when promoting metacognitive regulation (Hädwin, Järvelä, & Miller, 2011; Vauras & Volet, 2013). Collaborative learning is assumed to facilitate the adoption of regulation skills since it prompts students into collective goal setting, mutual control of each other's understanding and the group's progress, as well as evaluative reflections on learning strategies and outcomes (Hurme, Palonen, & Järvelä, 2006; Volet, Vauras, & Salonen, 2009). Despite growing consensus on the potential of collaborative learning, empirical research by means of direct observation of collaborative learners' metacognitive regulation in process-oriented studies, is limited (Hadwin et al., 2011; Iiskala, Vauras, Lehtinen, & Salonen, 2001; Rogat & Linnenbrink-Garcia, 2011; Roscoe, 2014). Little is known about the adoption of particular regulation skills, neither about the characteristics of the collaborative learning setting stimulating or hampering collaborative learners' regulative engagement (Hadwin et al., 2011). The present study aims at enhancing our understanding in this respect, by investigating the metacognitive regulation behaviour of higher education reciprocal peer tutoring (RPT) groups and its relationship with characteristics of RPT-groups' learning and interaction processes. More specifically, the relation with RPT-groups' content processing and the level of transactivity in their discussions is examined. Unlike most other research, this study does not focus exclusively on a particular regulation skill (e.g. monitoring), but takes an integrative perspective on collaborative learners' metacognitive regulation, investigating their adoption of orientation, planning, monitoring, and evaluation, as well as taking into account their low- and deep-level regulation approach. By unravelling the correlates of RPT-groups' differential engagement in specific regulation skills and approaches, the present study not only provides educators with concrete ideas on how to optimise collaborative learners' adoption of metacognitive regulation, but adds valuable insights into both the metacognition and the peer tutoring literature as well (Hadwin et al., 2011; Roscoe, 2014).

Theoretical framework

Metacognitive orientation, planning, monitoring, and evaluation

Metacognitive regulation refers to regulatory skills and strategies used by students to control, coordinate, and regulate their personal or a collaborative group's learning process (Hadwin et al., 2011; Meijer, Veenman, & van Hout-Wolters, 2006). We distinguish between orienting, planning, monitoring, and evaluating as key regulation skills (Brown, 1987; De Backer, Van Keer, & Valcke, 2012; Veenman, Elshout, & Meijer, 1997). When orienting, collaborative learners engage in task analysis and prior knowledge activation, to get acquainted with both learning objectives and each other's initial understanding (Butler, 2002). Planning encompasses selecting and sequencing problem solving strategies and developing action plans to tackle the group assignment (Meijer et al., 2006). Monitoring involves the quality control of the collaborative problem solving process, aimed at identifying inconsistencies and at optimising task execution (Meijer et al., 2006; Webb, 2009). It can be directed at students' comprehension, progress, or collaboration (Hurme et al., 2006; King, 1998; Veenman et al., 1997). Evaluation involves learners' self-judgements upon completion of collaborative learning, focussed on learning outcomes, the problem solving process, or group members' collaboration (Butler, 2002; Meijer et al., 2006).

Low-level and deep-level metacognitive regulation

The adoption of metacognitive regulation is linked to students' learning approach and characteristics of the collaborative learning process (Greene & Azevedo, 2007; Volet et al., 2009). Deep learning, aimed at integrated knowledge construction is often related to regulatory control and the adoption of sophisticated metacognitive strategies (Chin & Brown, 2000; Roscoe & Chi, 2007), whereas surface learning generally encourages students less to regulate (Greene & Azevedo, 2007; King, 1998).

Based on the typology of surface and deep approaches to learning, we distinguish low-level and deep-level metacognitive regulation, introducing a more in-depth operationalization (De Backer et al., 2012). Low-level orientation is directed at exploring task demands, whereas deep-level orientation involves processing task demands and activating prior knowledge (Butler, 2002). Low-level planning implies developing a single problem solving plan, whereas deep-level planning involves selecting a plan from problem-solving alternatives (Meijer et al., 2006; Veenman et al., 1997). When students check the groups' progress, collaboration, or their own or peers' understanding by means of information-reviewing statements, they engage in low-level monitoring. Reflective comments on the quality of the group's collaboration or perceived progress and elaborative statements regarding one's own or peers' understanding, imply deep-level monitoring (Roscoe & Chi, 2008). Correspondingly, low-level evaluation involves checking and commenting on either learning outcomes or process factors, whereas deep-level evaluation implies reflective judgements on both (Veenman et al., 1997).

Metacognitive learning in peer tutoring settings

Since fostering metacognitive regulation requires reflection and metacognitively-oriented interaction (Hadwin et al., 2011; Molenaar, 2011; Schunk & Zimmerman, 2007), collaborative learning is assumed to be a promising metacognitive facilitator. The present study investigates the metacognitive regulation behaviour of students participating in reciprocal peer tutoring and its relation with the ongoing peer interaction .

Peer tutoring (PT) is characterised by active academic helping and supporting between peers in small groups or pairs (Falchikov, 2001; Topping, 2005). One peer, the tutor, takes a direct pedagogical responsibility by creating learning opportunities through questioning, clarifying, and active scaffolding (Chi, Siler, Jeong, Yamauchi, & Hausmann, 2001; Duran & Monereo, 2005; Roscoe & Chi, 2008). The students being cognitively challenged by the peer tutor are called tutees. Reciprocal peer tutoring (RPT), in particular, is characterised by the structured exchange of the tutor role among peers in the PT-groups/pairs (Duran & Monereo, 2005; Topping, 2005) and enables each student to experience the specific benefits of providing and receiving academic guidance (Falchikov, 2001).

The open learning environment established in a PT-setting invites students to take responsibility for their own and peers' learning, including metacognitively regulating the collaborative learning process (Goos, Galbraith, & Renshaw, 2002; Hadwin et al., 2011; Volet et al., 2009). It provides tutors and tutees with a platform to adopt, train, and refine diverse regulation skills (King, 1998; Roscoe, 2014). Nevertheless, the PT-setting as such cannot guarantee students' involvement in diverse metacognitive regulation skills. Rather, it could be assumed that both group dynamics and characteristics of the collaborative learning process influence the opportunities to apply diverse regulation skills and approaches (Hadwin et al., 2011; Molenaar, 2011; Volet et al., 2009). The present study aims at enhancing our understanding in this respect by investigating the relation between RPT-groups' metacognitive regulation and their content processing on the one hand, transactive discussions on the other hand.

Content processing in PT-groups

Questioning and explaining are fundamental sources for content processing and knowledge (co-) construction in PT-settings (King, 1998; Roscoe & Chi, 2008; Webb, Ing, Kersting, & Nemer, 2006). Tutorial dialogues are frequently characterised by peer tutors providing explanations to convey knowledge and to make information comprehensible (Roscoe & Chi, 2008) or to correct tutees' misconceptions (Webb, 2009). Similarly, tutees often engage in self-explanations, aimed at feedback from the PT-group (Chi et al., 2001). Additionally, peer tutors ask questions to guide and assess tutees' understanding and to inquire about the PT-group's progress (Graesser & Person, 1994; King, 1998), whereas tutees ask for clarification after conceptual confusion, for additional information when integrating new and prior knowledge, and for evaluation of interpretations or proposed problem solving actions (Chi et al., 2001; Webb et al., 2006).

Given that questioning and explaining elicit the mutual exchange of ideas, invoking cognitive restructuring and reflection on one's own and each other's learning, both content processing strategies might have the potential to elicit students' engagement in metacognitive regulation (King, 1998; Rogat & Linnenbrink-Garcia, 2011). More specifically, higher-order content processing, such as thought-provoking questioning or knowledge-building explaining – aimed at integrating, justifying, and elaborating on information (Graesser & Person, 1994; Roscoe & Chi, 2008) – might encourage the revision of mental models and problem solving strategies, directly addressing students' metacognitive regulation (Rogat & Linnenbrink-Garcia, 2011; Volet et al., 2009). In contrast, lower-order content processing – characterised by factual questions and knowledge-reviewing explanations (Graesser & Person, 1994; Roscoe & Chi, 2008) – might evoke less cognitive restructuring and consequently less metacognitive regulation (King, 1998; Volet et al., 2009). Although it seems plausible that collaborative learners' content processing and metacognitive regulation are connected, few empirical evidence is available on the differential relation of content processing strategies and particular regulation skills or approaches.

Transactive discussions

Since knowledge co-construction and joint problem solving require students to discuss and decide upon the content and organisation of collaborative learning – facilitating their regulative acts (Hurme et al., 2006; King, 1998) – the reciprocity of peers' interactions might be decisive for collaborative learners' adoption of metacognitive regulation (Goos et al., 2002). In the present study, we refer to students' reciprocal contributions to the RPT-interactions as transactive discussions (King, 1998; Noroozi, Teasley, Biemans, Weinberger, & Mulder, 2013). Transactivity is more specifically conceptualised as a conversational mode in which students' statements operate on previously expressed reasoning of each other *(other-oriented)* or themselves *(self-oriented)* (Berkowitz, Althof, Turner, & Bloch, 2008; Teasley, 1997). Low transactive (i.e. representational) discussions, in which students' contributions merely represent previously articulated statements, appear to hamper learning (Webb et al., 2006; Weinberger, Stegmann, & Fischer, 2007). In contrast, highly transactive (i.e. operational) discussions, characterised by conversational connectedness and elaborative transformation of peers' thinking, are positively correlated to students' reasoning and active knowledge construction (Berkowitz et al., 2008; Teasley, 1997; Webb, 2009; Weinberger et al., 2007). Goos et al. (2002) moreover directly related highly transactive discussions to collaborative learners' involvement in metacognitive regulation. They found that the proportion of transactive discussions between collaborative learners was beneficial for successful collaborative problem solving, due to students' enhanced monitoring of each other's thinking.

Since collaborative learners are responsible for shaping their learning activities, as well as for metacognitively regulating the collaborative learning process, their transactive discussions can be centred around both cognitive and metacognitive discourse (Goos et al., 2002; Hurme et al., 2006). Although it seems plausible that in particular highly-interactive peer discussions with a direct focus on metacognitive discourse can facilitate students' adoption of metacognitive regulation, the relation between collaborative learners' transactive discussions and particular regulation skills, as well as regulation approaches, is empirically underexposed.

Aim of the study

Although collaborative learning appears promising to foster students' metacognitive regulation (De Backer, Van Keer, Moerkerke, & Valcke, in press; Hurme et al., 2006; King, 1998), little is known about collaborative learners' differential involvement in specific regulation skills or low- versus deep-level regulation, neither about the stimulating/hampering factors influencing collaborative learners' adoption of particular regulation skills and approaches. The present study aims at analysing whether and how RPT-participants' content processing and transactive discussions are related to their metacognitive regulation behaviour. The following research questions are put forward:

(1) What is the relation between RPT-groups' involvement in (a) particular regulation skills (i.e. orienting, planning, monitoring, and evaluating) and their adopted content processing strategies (i.e. questioning and explaining); (b) a deep-level regulation approach and the lower- versus higher-order nature of their content processing?

(2) What is the relation between RPT-groups' involvement in (a) particular regulation skills (i.e. orienting, planning, monitoring, and evaluating) and the occurrence of cognitively-oriented and metacognitively-oriented transactive discussions; (b) a deep-level regulation approach and the low versus high transactive nature of their cognitively-oriented and metacognitively-oriented discussions?

Method

Participants and setting

The study was conducted in a naturalistic university setting. Sixty-four first-year Educational Sciences students who already obtained a Professional Bachelor degree (12.5% males, 87.5% females) were randomly assigned to eleven RPT-groups. The RPT-programme was a formal component of a 5-credit course "Instructional Sciences". Informed consent was obtained from the participants.

RPT-intervention

The RPT-intervention consisted of eight successive face-to-face sessions (including a training session) of two hours each. Students tutored each other in stable groups of six. The tutor role was randomly appointed to students by a university staff member and interchanged at each session within each RPT-group. During each RPT-session, the tutor was primarily responsible for managing the interactions and stimulating collaborative learning, whereas tutees were occupied with solving the group assignment. As a manipulation check, all RPT-groups were observed weekly, to control whether tutors and tutees enacted their roles adequately.

RPT-assignments

During each RPT-session, students worked on authentic group assignments, linked to themes in the course "Instructional Sciences" (De Backer et al., 2012). The assignments were presented as open-ended tasks requiring students' collaboration and high levels of cognitive processing. Each assignment consisted of an outline of learning objectives; a subtask to get familiar with theme-specific terminology; and a subtask to apply theory to real-life cases. Despite differences in the central topic, all assignments addressed comparable learning experiences during each RPT-session.

Training

Students participated in a compulsory preliminary tutor training, one week before the onset of the RPT-intervention. During this training, students were informed about the multidimensional tutor responsibilities and applied a mix of generic tutoring skills. The focus was on establishing a safe learning climate (Barron, 2003; Falchikov, 2001); managing and stimulating interactions (Chi et al., 2001; Webb, 2009); asking differentiated questions (Graesser & Person, 1994; King, 1998); giving constructive feedback (Webb et al., 2006); providing comprehensive explanations (Roscoe & Chi, 2008), and scaffolding tutees' learning (Chi et al., 2001; Molenaar, 2011). The outlines of the tutor training were summarised in a 9-page manual provided to all students.

Tutor guide

To prepare themselves, peer tutors received a session-specific “tutor guide” one week in advance. This guide consisted of a 10-page manual and offered additional information about the theory to focus upon in the RPT-session, for the PT-literature stresses the necessity of a difference in peer tutors’ and tutees’ domain-specific knowledge (Falchikov, 2001; Topping, 2005). The tutor guide also inspired students to tackle problem solving stepwise, by offering examples to explore task demands, develop actions plans, verify whether task requirements are met, and reflect on the RPT-session. These problem solving steps were depicted in a schematic overview, provided to each tutor (De Backer et al., 2012).

Interim support

To provide support to students, both interim supervision sessions (taking two hours) and two-weekly feedback sessions (each taking 30 minutes) were organised. Halfway through the RPT-intervention, compulsory supervision sessions were organised for all students. The supervision sessions were set up in small groups of twelve students (recruited from two randomly selected RPT-groups) and directed by a staff member, who encouraged students to reflect on their behaviour as tutor and tutee. Additionally, the staff member provided group-specific feedback every two weeks, focusing on group dynamics, peer collaboration, equal contribution of tutees, and students’ tutoring approach. The feedback resulted in group reflections and action plans to optimise peer collaboration.

Data collection

All RPT-sessions of five randomly selected RPT-groups of six students were videotaped (70 hours of recordings). The video-data provided real-time information about tutors’ and tutees’ learning activities, including their metacognitive regulation.

Coding instruments

To examine students’ learning and metacognitive regulation in the RPT-groups, diverse coding instruments were designed, addressing the variables in the abovementioned research questions. First, utterances of metacognitive regulation were identified using the RPT_MCR instrument (i.e. RPT-groups’ metacognitive regulation; De Backer et al., in press), which incorporates literature on both metacognitive regulation (e.g. Meijer et al., 2006; Veenman et al., 1997) and tutoring/peer interactions (e.g. King, 1998; Roscoe & Chi, 2008; Webb et al., 2006). The instrument represents a multi-layered model of metacognitive regulation in collaborative settings. Orientation, planning, monitoring, and evaluation are adopted as the main coding categories and specified with sub-coding categories (i.e. task analysis, activating prior knowledge, task perceptions, planning in advance, interim planning, monitoring of comprehension, monitoring of progress, monitoring of collaboration, evaluation of learning outcomes, evaluation of the learning process, and evaluation of collaboration). Additionally, a dimension on the approach to metacognitive regulation is included, identifying the low-/deep-level nature of regulation strategies in the sub-coding categories. Both the metacognitive strategies and the regulative approaches are developed from the literature on metacognitive regulation, as presented in the theoretical part of this article.

Second, the coding instrument RPT_CON (i.e. RPT-groups' content processing, De Backer, Van Keer, & Valcke, 2015) was developed to capture students' content processing strategies. Questioning and explaining served as the main coding categories. Questioning is defined as an interrogative statement in which a student requests information (Roscoe & Chi, 2008). We further distinguish factual questioning (i.e. lower-order knowledge-reviewing questions aimed at inquiring about facts, terminology, or information explicitly addressed previously) and thought-provoking questioning (implying higher-order processing by means of thinking, probing, and hinting inquiries that manifest elaborative reasoning and ask about information not previously mentioned) as sub-coding categories (Graesser & Person, 1994; King et al., 1998). Explaining is conceptualised as providing informative statements, aimed at conveying knowledge and making information comprehensible (Barron, 2003; Chi et al., 2001; Webb, 2009). Lower-order knowledge-telling (involving factual, paraphrasing, or unelaborated explanations) and higher-order knowledge-building (representing reflective conceptual reasoning, elaborative rethinking of information, and active knowledge-construction) are distinguished as sub-coding categories (Roscoe & Chi, 2008; Webb, 2009).

Third, the coding instrument RPT_TRANS (i.e. RPT-groups' transactive discussions; De Backer et al, 2015) was adopted from Berkowitz et al. (2008) to code the level of transactivity in RPT-participants' interactions. The present study conceptualises transactivity as an other-oriented interactional mode at the dyadic level in which a student responds to his conversational partner's cognitively-oriented (Teasley, 1997; Webb, 2009; Weinberger et al., 2007) or metacognitively-oriented (Goos et al., 2002; Molenaar, 2011) statements to clarify, complete, or criticise the partner's cognitive/metacognitive reasoning. The instrument distinguishes representational transactivity (referring to low transactive exchanges merely representing a peer's reasoning), operational transactivity (encompassing high transactive exchanges transforming a peer's thinking), hybrid transactivity (being partly representational, partly operational, consisting of completions of peers' statements or paraphrases highlighting the inconsistency in their reasoning), and non-transactivity (referring to all exchanges not classified as transactive) as coding categories (Berkowitz et al., 2008).

Coding strategy

The coding procedure followed subsequent phases and exclusively focussed on students' verbalised interaction. First, each RPT-session was divided into broad segments by means of episode coding, according to changes in the topic of discussion (Chi et al., 2001). An episode is conceptualised as a rather large segment (including multiple conversational turns) of the overall interaction that was centred around one particular topic of discussion. After segmentation, each episode was labelled as metacognitive regulation, content processing, task-execution, or off-task behaviour.

Second, both metacognitive and content processing episodes were analysed further for more detailed statement coding (Roscoe & Chi, 2008). A statement (representing a single conversational turn) refers to a single thematically consistent verbalisation of a single metacognitive/content processing action by a single student. The identified metacognitive statements were coded with RPT_MCR, whereas the content processing statements were coded by means of RPT_CON. Each statement represented the multi-layered nature of the respective coding instrument: every statement received a general code (indicating the regulation skill, respectively content processing strategy it addressed) and a specific code (referring to the concretised regulation strategies, respectively the lower- versus higher-order nature of content processing, in the sub-coding categories of both coding instruments).

Third, the transactivity in RPT-groups' discussions was coded by means of interaction coding (Chi et al., 2001) of previously coded statements in the segmented metacognitive and content processing episodes. This coding focussed on the statements students articulated as a reaction to previously expressed metacognitive regulation, respectively content processing. Transactive units therefore represented two conversational turns (i.e. action-reaction exchange between two students) within the selected episodes (Roscoe & Chi, 2008). Only metacognitive reactions to metacognitive statements were segmented as a metacognitively-oriented transactive unit. Correspondingly, cognitively-oriented transactive units required a content processing reaction to cognitive reasoning. After segmentation of the interactive units in the metacognitive, respectively content processing episodes, each unit was allocated a code from RPT_TRANS, indicating the level of transactivity. Appendix A exemplifies both statement and interaction coding.

Coding the video data was accomplished by two independent and trained coders. They double-coded 25% of the recorded sessions (8781 statements) to determine interrater reliability. Cohen's kappa indicates high interrater reliability for the coding of 'metacognitive regulation' (κ = .89) and good agreement beyond chance for the four main coding categories ($\kappa_{orientation}$=.81, $\kappa_{planning}$ =.93, $\kappa_{monitoring}$ =.92, and $\kappa_{evaluation}$=.88). The interrater reliability for coding 'content processing' was equally high, as well as for the corresponding subcategories ($\kappa_{questioning}$ =.89, $\kappa_{explaining}$ =.93). Cohen's kappa further indicates high agreement for coding the approach to regulation ($\kappa_{approach\_metacognition}$ =.93) and the lower- versus higher-order nature of content processing ($\kappa_{approach\_cognition}$ =.96). High interrater reliability was reported for coding the level of transactivity in both metacognitively-oriented ($\kappa_{transactivity\_metacognition}$ =.88) and cognitively-oriented discussions ($\kappa_{transactivity\_cognition}$ =.91).

Data analysis

After coding the video data, the frequency of occurrence of metacognitive/content processing statements and transactive units was calculated for each RPT-group and session. In total, 14968 metacognitive statements were identified, 11356 content processing statements, 6837 cognitively-oriented transactive units, and 5716 metacognitively-oriented transactive units. The relationships between RPT-groups' metacognitive regulation and their content processing on the one hand, their transactive discussions on the other hand were studied over all RPT-groups and RPT-sessions by means of binary logistic regression analyses. In a first model, the occurrence of metacognitive regulation (i.e. occurrence versus non-occurrence) served as binary dependent variable. The occurrence (versus non-occurrence) of questioning, explaining, cognitively-oriented and metacognitively-oriented non-transactive discussions, and cognitively-oriented and metacognitively-oriented transactive discussions served as independent variables. In a second model, the occurrence (i.e. occurrence versus non-occurrence) of deep-level metacognitive regulation served as binary dependent variable. In this second model, the occurrence (versus non-occurrence) of lower-order versus higher-order questioning and explaining, representational versus operational cognitively-oriented transactive discussions, and representational versus operational metacognitively-oriented transactive discussions[1] served as independent variables. All independent variables in both logistic regression models were treated as binary. The absence of utterances regarding the abovementioned independent variables served as reference category in each model. Both logistic regression models were run with each key regulation skill (i.e. orienting, planning, monitoring, evaluating) as binary dependent variable.

To analyse the strength of identified significant relations, odds ratios were calculated. The significance level was set at .05 for all analyses.

Results

Descriptive analysis

Before addressing the relation between RPT-groups' metacognitive regulation and their content processing and transactive discussions, descriptive information is presented. Data from the RPT-sessions were clustered in three phases, to unravel evolutions from the starting (sessions 1-2) over the intermediate (sessions 3-4) to the closing (sessions 5-7) phase.

Metacognitive regulation

In general, RPT-groups are predominantly involved in cognitive activities (53.2%), aimed at problem solving and processing new knowledge, and in metacognitive regulation of these activities (43.6%). They limitedly engage in off-task discussions (3.2%). Table 1 demonstrates increased metacognitive regulation, more specifically orientation, evaluation, and monitoring. Whereas problem solving initially starts without much orientation (1.8%), RPT-groups increasingly orient themselves halfway (4.2%) and in the closing phase (5.2%). Similarly, adoption of evaluation grows from the starting (1.4%) over the intermediate (2.8%) to the closing phase (4.3%). Table 1 further

[1] Given their low frequency of occurrence, both cognitively-oriented and metacognitively-oriented hybrid transactive discussions (see Table 1) were excluded from logistic regression analysis.

reveals a dominance of monitoring in all phases. Despite increased monitoring at the intermediate and the closing phase, this evolution is smaller compared to the trends in orientation and evaluation. In contrast, planning remains limited and is rather stable.

Table 2 reveals an initial, almost exclusive adoption of low-level regulation. Although RPT-groups' engagement in deep-level regulation is negligible in the starting phase (3.2%), it gradually grows at the intermediate (9.7%) and the closing phase (14.8%). This evolution towards adopting a deep-level regulation approach more frequently is, however, not present in all regulation skills. RPT-groups' deep-level planning and deep-level evaluation are negligible throughout all phases (see Table 2). In contrast, the adoption of deep-level orientation grows from the starting (1.0%) to the closing phase (4.7%). Table 2 reveals moreover that orientation becomes dominantly deep-level at the closing phase. Despite an additional increase in deep-level monitoring from the starting (2.0%) to the closing phase (8.8%), RPT-groups' monitoring remains mainly low-level (see Table 2)[2].

Content processing

RPT-groups are generally more frequently involved in explaining (23.1%) than in questioning (10.1%). The occurrence of both remains, however, stable (see Table 1). A different evolution pattern is revealed when taking into account lower-versus higher-order content processing. Initially, RPT-groups almost exclusively apply lower-order content processing, whereas they demonstrate increased adoption of thought-provoking questioning (3.9%) and knowledge-building explaining (5.5%) at the closing phase.

Transactive discussions

RPT-participants react more upon each other's previously expressed reasoning (82.7%) than they ignore peers' contributions (17.3%). RPT-groups' cognitively-oriented transactive discussions outnumber their metacognitively-oriented transactive discussions (see Table 1). Nevertheless, students increasingly engage in the latter from the starting (30.5%) to the closing phase (39.0%). Table 1 further shows increased operational transactive discussions, although representational transactive discussions remain dominant, both when cognitively-oriented and metacognitively-oriented.

[2] Content processing, metacognitive, or transactive utterances with very low frequencies of occurrence (<2%) were excluded from further logistic regression analysis.

Table 1. *Frequency of occurrence of metacognitive regulation, content processing, and transactive discussions in RPT-groups during the three intervention phases (frequencies and percentages)*

	starting phase		intermediate phase		closing phase	
	frequency	*%*	*frequency*	*%*	*frequency*	*%*
METACOGNITIVE REGULATION (TOTAL)	**3079**	**38.7**	**4128**	**43.1**	**7761**	**46.3**
Orientation	**145**	**1.8**	**402**	**4.2**	**869**	**5.2**
task analysis	56	0.7	109	1.1	194	1.2
activation prior knowledge	60	0.8	288	3.0	654	3.9
task perceptions	29	0.3	5	0.1	21	0.1
Planning	**227**	**2.9**	**304**	**3.2**	**541**	**3.2**
planning in advance	13	0.2	17	0.2	22	0.1
interim planning	214	2.7	287	3.0	519	3.1
Monitoring	**2593**	**32.6**	**3150**	**32.9**	**5626**	**33.5**
comprehension monitoring	1832	23.1	2274	23.7	3882	23.1
monitoring of progress	731	9.2	758	7.9	1551	9.2
monitoring of collaboration	30	0.3	118	1.2	193	1.2
Evaluation	**114**	**1.4**	**272**	**2.8**	**723**	**4.3**
evaluation of outcomes	42	0.5	85	0.9	373	2.2
evaluation of process	54	0.7	129	1.3	253	1.5
evaluation of collaboration	18	0.2	58	0.6	97	0.6
CONTENT PROCESSING (TOTAL)	**2652**	**33.4**	**3250**	**33.9**	**5454**	**32.5**
questioning	**840**	**10.6**	**998**	**10.4**	**1567**	**9.3**
factual questioning (lower-order)	750	9.4	726	7.6	906	5.4
thought-provoking questioning (higher-order)	90	1.1	272	2.8	661	3.9
explaining	**1812**	**22.8**	**2252**	**23.5**	**3887**	**23.2**
knowledge-telling (lower-order)	1740	21.9	1928	20.1	2969	17.7
knowledge-building (higher-order)	72	0.9	324	3.4	918	5.5
TRANSACTIVE DISCUSSIONS (TOTAL)	**2951**	**100**	**3564**	**100**	**6038**	**100**
cognitively-oriented transactive discussions	**1695**	**57.2**	**2015**	**57.2**	**3127**	**51.8**
non-transactive discussions	246	8.3	223	6.3	332	5.4
transactive discussions	1449	48.9	1792	50.8	2795	46.5
representational discussions	1381	46.8	1492	42.3	2098	34.9
hybrid discussions	28	0.8	84	2.4	51	0.8
operational discussions	40	1.3	216	6.1	646	10.8
metacognitively-oriented transactive discussions	**1256**	**42.8**	**1549**	**42.8**	**2911**	**48.2**
non-transactive discussions	362	12.3	357	10.1	554	9.2
transactive discussions	894	30.5	1195	33.8	2357	39.0
representational discussions	833	28.4	976	27.7	1853	30.8
hybrid discussions	40	1.4	36	1.0	23	0.3
operational discussions	21	0.7	180	5.1	481	7.9

Table 2. *Frequency of occurrence of low-level and deep-level metacognitive regulation in RPT-groups during the three intervention phases (frequencies and percentages)*

approach to metacognitive regulation	**starting phase**		**intermediate phase**		**closing phase**	
	frequency	*%*	*frequency*	*%*	*frequency*	*%*
low-level	**2757**	**34.7**	**3163**	**33.1**	**5212**	**31.1**
orientation	43	0.5	55	0.6	64	0.4
planning	217	2.7	291	3.0	477	2.8
monitoring	2389	30.1	2598	27.2	4108	24.5
evaluation	108	1.4	219	2.3	563	3.4
deep-level	**250**	**3.2**	**929**	**9.7**	**2486**	**14.8**
orientation	76	1.0	344	3.6	786	4.7
planning	9	0.1	13	0.1	62	0.4
monitoring	159	2.0	519	5.4	1478	8.8
evaluation	6	0.1	53	0.6	160	0.9

The relation between RPT-groups' content processing and their regulation

Our results reveal a significant association for RPT-groups' metacognitive regulation and content processing. Table 3 shows that both questioning and explaining significantly increase the probability of metacognitive regulation (both p<.001). RPT-groups are 4.67 times more likely to regulate during questioning and 1.23 times when providing explanations. It furthermore reveals a significant positive correlation between RPT-groups' higher-order content processing and their adoption of deep-level metacognitive regulation. The odds of deep-level regulation increase 7.85 times when asking thought-provoking questions (p<.001), whereas they increase 6.61 times during knowledge-building explaining (p<.001). In contrast, lower-order content processing significantly decreases (p<.001) the probability of deep-level metacognitive regulation (see Table 3).

Additional analyses with respectively orientation, planning, monitoring, and evaluation as dependent variable demonstrate that the abovementioned correlations cannot be revealed for all regulation skills. Only monitoring is significantly and positively associated with both questioning and explaining (both p<.001, see Table 4). RPT-groups are 9.12 times more likely to monitor their learning when asking questions and 2.27 times when providing explanations. Although the occurrence of orientation and evaluation is not significantly associated with RPT-groups' questioning (p=.239 and p=.856, respectively), the probability of both regulation skills significantly increases when explanations are provided (both p<.001). During explaining, the odds of orientation increase 2.92 times, whereas the odds of evaluation become 4.55 times larger. In contrast, the occurrence of planning is not significantly associated with explaining (p=.137), neither with questioning (p=.140).

Regarding the approach, Table 5 reveals a significant positive correlation of deep-level monitoring with both higher-order questioning and explaining (both p<.001). RPT-groups are 8.74 times more likely to adopt deep-level monitoring during thought-provoking questioning and 5.41 times more during knowledge-building explaining. Deep-level monitoring is, however, significantly negatively associated with lower-order content processing (p<.001, see Table 5). In contrast, deep-level orientation is not significantly correlated with lower-order questioning and explaining (p=.098 and *p*=.417, respectively), neither with higher-order questioning (*p*=.627), but does significantly increase when RPT-groups provide knowledge-building explanations (*p*<.001). Deep-level orientation is, more specifically, 9.71 times more likely to occur during higher-order explaining.

The relation between RPT-groups' transactive discussions and their regulation

The results indicate that RPT-groups' non-transactive discussions are not significantly correlated with their adoption of metacognitive regulation (see Table 3). In contrast, both cognitively-oriented and metacognitively-oriented transactive discussions significantly increase the probability of metacognitive regulation (both *p*<.001). RPT-groups are 1.54 times more likely to regulate during cognitively-oriented transactive discussions and 1.67 times more during metacognitively-oriented transactive discussions.

Table 3. *Logistic regression estimates for the occurrence of metacognitive regulation and a deep-level regulation approach*

	Estimate	*SE*	*Wald*	*df*	*p*	*OR*	OR^{-1}	*95%CI*
OCCURRENCE OF METACOGNITIVE REGULATION								
content processing								
questioning	1.54	0.04	134.77	1	.000	4.67		[0.81, 0.89]
explaining	0.21	0.03	65.93	1	.000	1.23		[0.08, 0.15]
transactive discussions								
CO non-transactive	0.03	0.08	0.16	1	.685	1.03		[0.07, 0.10]
CO transactive	0.44	0.03	214.17	1	.000	1.55		[0.21, 0.28]
MO non- transactive	-0.03	0.07	0.19	1	.666	0.97	1.03	[-0.09, 0.06]
MO transactive	0.51	0.03	229.55	1	.000	1.67		[0.25, 0.31]
APPROACH TO METACOGNITIVE REGULATION								
content processing								
LO questioning	-2.74	0.26	111.03	1	.000	0.65	1.54	[-1.79, -1.23]
HO questioning	2.06	0.07	391.07	1	.000	7.85		[1.06, 1.21]
LO explaining	-1.46	0.09	286.87	1	.000	0.23	4.31	[-0.90, -0.71]
HO explaining	1.88	0.06	204.30	1	.000	6.61		[0.97, 1.10]
transactive discussions								
representational CO	0.70	0.05	226.84	1	.000	2.01		[0.33, 0.44]
operational CO	1.06	0.09	144.49	1	.000	2.90		[0.49, 0.68]
representational MO	0.76	0.05	220.72	1	.000	2.14		[0.36, 0.47]
operational MO	1.21	0.10	152.89	1	.000	3.34		[0.56, 0.78]

Note: CO= cognitively-oriented; MO= metacognitively-oriented; LO=lower-order, HO=higher-order; OR= odds ratio; OR^{-1}= inverse odds ratio; CI= confidence interval

Table 3 furthermore reveals a significant positive association for RPT-groups' adoption of deep-level metacognitive regulation and both their representational and operational cognitively-oriented and metacognitively-oriented transactive discussions. Although the probability of deep-level regulation is especially increased during operational metacognitively-oriented discussions (3.34 times; *p*<.001), rather comparable odds for deep-level regulation are shown for representational transactive discussions, as well as for operational cognitively-oriented discussions (see Table 3). Additional analyses with respectively orientation, planning, monitoring, and evaluation as dependent variable demonstrate that the abovementioned correlations cannot be revealed for all regulation skills. The occurrence of planning and evaluation is not significantly associated with cognitively-oriented (p=.432 and p=.189, respectively), neither with metacognitively-oriented transactive discussions (p=.179 and p=.338, respectively). In contrast, the probability of orientation and monitoring is significantly increased during both cognitively-oriented (both p<.001) and metacognitively-oriented transactive discussions (both p<.001). Table 4 reveals that the odds of both regulation skills are comparably increased during cognitively-oriented and metacognitively-oriented transactive discussions. Similarly, RPT-groups' deep-level approach when orienting and monitoring is significantly and positively associated with both representational and operational cognitively-oriented and metacognitively-oriented transactive discussions (p<.001, see Table 5). The level of transactivity in both types of discussions does moreover not show a differential relationship: the odds of deep-level orientation and monitoring are comparably increased during representational and operational cognitively-oriented and metacognitively-oriented transactive discussions (see Table 5).

Table 4. *Logistic regression estimates for the occurrence of orientation, planning, monitoring, and evaluation*

	Estimate	*SE*	*Wald*	*df*	*p*	*OR*	OR^{-1}	*95% CI*
ORIENTATION								
content processing								
questioning	0.53	0.45	1.39	1	.239	1.71		[-0.19, 0.77]
explaining	1.07	0.30	12.66	1	.000	2.92		[0.27, 0.91]
transactive discussions								
CO non-transactive	0.02	0.15	0.02	1	.901	1.02		[-0.15, 0.17]
CO transactive	1.35	0.07	305.56	1	.000	3.86		[0.69, 0.82]
MO non- transactive	0.11	0.12	0.90	1	.343	1.12		[-0.07, 0.19]
MO transactive	1.49	0.07	306.07	1	.000	4.44		[0.75, 0.90]
PLANNING								
content processing								
questioning	1.22	0.50	6.02	1	.140	3.38		[0.13, 1.21]
explaining	0.65	0.44	2.21	1	.137	1.91		[-0.12, 0.83]
transactive discussions								
CO non-transactive	0.18	0.23	0.62	1	.431	1.19		[-0.15, 0.35]
CO transactive	-0.08	0.10	0.61	1	.432	0.92	1.08	[-0.15, 0.06]
MO non- transactive	0.11	0.18	0.34	1	.558	1.11		[-0.13, 0.26]
MO transactive	0.28	0.21	1.80	1	.179	1.32		[-0.07, 0.38]
MONITORING								
content processing								
questioning	2.21	0.04	270.83	1	.000	9.12		[1.18, 1.26]
explaining	0.82	0.03	348.11	1	.000	2.27		[0.42, 0.49]
transactive discussions								
CO non-transactive	0.07	0.09	0.67	1	.413	1.07		[-0.06, 0.14]
CO transactive	0.16	0.03	24.56	1	.000	1.18		[0.06, 0.12]
MO non- transactive	-0.10	0.07	1.95	1	.163	0.90	1.11	[-0.13, 0.02]
MO transactive	0.19	0.04	25.63	1	.000	1.21		[0.06, 0.15]
EVALUATION								
content processing								
questioning	0.01	0.05	0.03	1	.856	1.01		[-0.05, 0.07]
explaining	1.52	0.40	40.07	1	.000	4.55		[0.41, 1.27]
transactive discussions								
CO non-transactive	0.06	0.54	0.01	1	.916	1.06		[-0.55, 0.62]
CO transactive	0.27	0.20	1.72	1	.189	1.30		[-0.07, 0.36]
MO non- transactive	-0.01	0.46	0.01	1	.984	0.99	1.01	[-0.55, 0.44]
MO transactive	0.20	0.20	0.92	1	.338	1.22		[-0.11, 0.33]

Note: CO= cognitively-oriented; MO= metacognitively-oriented; OR= odds ratio; OR^{-1}= inverse odds ratio; CI= confidence interval

Table 5. *Logistic regression estimates for the occurrence of deep-level orientation and deep-level monitoring*

	Estimate	*SE*	*Wald*	*df*	*p*	*OR*	*OR^{-1}*	*95% CI*
DEEP-LEVEL ORIENTATION								
content processing								
LO questioning	1.01	0.61	2.75	1	.098	2.75		[-0.10, 1.22]
HO questioning	-0.51	1.05	0.24	1	.627	0.60	1.64	[-1.42, 0.82]
LO explaining	0.37	0.45	0.66	1	.417	1.44		[-0.28, 0.69]
HO explaining	2.27	0.55	16.92	1	.000	9.71		[0.66, 1.85]
transactive discussions								
representational CO	1.15	0.07	240.14	1	.000	3.16		[0.55, 0.71]
operational CO	1.20	0.14	70.67	1	.000	3.32		[0.51, 0.81]
representational MO	1.23	0.08	239.58	1	.000	3.41		[0.59, 0.76]
operational MO	1.29	0.15	70.31	1	.000	3.64		[0.55, 0.87]
DEEP-LEVEL MONITORING								
content processing								
LO questioning	-2.32	1.00	18.62	1	.000	0.11	9.34	[-2.36, -0.20]
HO questioning	2.17	0.08	288.90	1	.000	8.74		[1.11, 1.28]
LO explaining	-1.92	0.18	108.12	1	.000	0.15	6.80	[-1.25, -0.86]
HO explaining	1.69	0.07	302.69	1	.000	5.41		[0.86, 1.01]
transactive discussions								
representational CO	0.25	0.08	9.83	1	.002	1.29		[0.05, 0.22]
operational CO	0.68	0.15	19.76	1	.000	1.98		[0.21, 0.54]
representational MO	0.27	0.09	8.77	1	.003	1.31		[0.05, 0.25]
operational MO	0.76	0.17	19.87	1	.000	2.15		[0.24, 0.60]

Note: CO= cognitively-oriented; MO= metacognitively-oriented; LO= lower-order; HO= higher-order; OR= odds ratio; OR^{-1}= inverse odds ratio; CI= confidence interval

Discussion

The present study aimed at investigating how RPT-groups' content processing and transactive discussions are related to their adoption of orientation, planning, monitoring, and evaluation, as well as to their adoption of a deep-level regulation approach. By acknowledging the differential correlations of content processing and transactive discussions with particular regulation skills and approaches, the present study provides innovative insights which enhance our theoretical knowledge of collaborative learners' metacognitive regulation and which allow educators to optimally foster students' regulation behaviour.

The relation between RPT-groups' content processing and their metacognitive regulation

The present study revealed a significant positive association of RPT-groups' content processing and metacognitive regulation. Whereas questioning appeared especially important for RPT-groups' adoption of monitoring, explaining was shown to be conducive for the use of orientation and evaluation. Planning was not significantly correlated to RPT-groups' content processing. Given that regulation skills each have distinct features, despite being closely intertwined (Meijer et al., 2006), it should not be surprising that eliciting particular regulation skills is facilitated by different processing strategies.

The strong correlation between questioning and monitoring could be explained by the RPT-format (King, 1998; Roscoe, 2014). Tutors questioning the organisation and content of tutees' problem solving and tutees clarifying their thinking in reaction to these questions, often results in both tutors and tutees reflecting on their problem solving and comprehension, as well as in additional questioning (Chi et al., 2008; Hurme et al., 2006). In line with previous research (e.g. King, 1998; Roscoe, 2014), the present study suggests that RPT-participants' questions directly elicit monitoring. The finding that orientation and evaluation are correlated with explaining might be due to the nature of these regulation skills. During orientation, RPT-groups mainly activate prior knowledge (Butler, 2002), which implies explaining one's interpretations to the group, before extensively inquiring about them. After such episodes of inquiring, discussions are often summarised by tutors' evaluative explanations before addressing a next topic or before completing the assignment (Roscoe & Chi, 2008).

Our results further revealed a positive association of RPT-groups' higher-order content processing and deep-level monitoring and orientation. Since higher-order content processing often evokes revision of mental models (King, 1998; Rogat & Linnenbrink-Garcia, 2011) and given that questioning and explaining are especially applied when students process knowledge (e.g. during comprehension monitoring or when activating prior knowledge) (Chi et al., 2001; Graesser & Person, 1994), it should not be surprising that RPT-groups' higher-order content processing particularly elicited deep-level monitoring and orientation. The PT-setting might also have contributed, for deep-level regulation requires both extensive regulative practice and explicit metacognitive prompts (Chin & Brown, 2000; Schunk & Zimmerman, 2007). Since tutors generally dominate the PT-discussions, acting as (meta)cognitive models (Roscoe & Chi, 2008), their higher-order content processing might have been perceived as directly observable metacognitive prompts by tutees. In contrast, when tutors shared their thinking by means of knowledge-telling, they probably assessed their problem solving less openly (Chi et al., 2001), limiting tutees' opportunities to practice tutor-modelled regulation and to evolve towards a deep-level approach. This might also explain why lower-order content processing was negatively correlated with RPT-groups' adoption of deep-level regulation.

The relation between RPT-groups' transactive discussions and their metacognitive regulation

In line with previous research (Goos et al., 2002; Iiskala et al., 2011), ignoring peers did not evoke regulative acts. In contrast, RPT-groups' transactive discussions and metacognitive regulation were strongly correlated, more specifically during orientation and monitoring. Our findings suggest that transactive discussions especially occurred when students spontaneously shared, compared, and challenged their own or each other's understanding to co-construct knowledge, stimulating them to activate prior knowledge during orientation or to monitor their comprehension. Students do, however, not always criticise each other but rather pursue quick consensus-building, hampering transactive discussions (Molenaar, 2011; Weinberger et al., 2007). This might have been demonstrated during planning and evaluation, for example to ensure efficient problem solving. Further, students' perceptions of tutors' and tutees' responsibilities should be acknowledged since these might influence students' engagement in PT (Robinson, Schofield, & Steers-Wentzell, 2005). Tutor's responsibility towards the PT-group might have given them the status of decision-maker during planning and evaluation. Therefore, their suggested problem solving tactics or evaluative comments might have been more easily accepted, resulting in low transactive discussions. In contrast, orientation and monitoring might have been perceived as shared responsibilities between tutors and tutees, given that PT-contexts spontaneously invite tutees to share and discuss their thinking, facilitating transactive discussions.

Surprisingly, our findings revealed that transactive discussions do not necessarily have to be metacognitively-oriented for students to inspire each other to contribute to the group's regulation. Taking into account the positive correlation of RPT-groups' metacognitive regulation and cognitive processing, it seems plausible that peer discussions in which students react upon each other's questions or explanations facilitate the initiation of regulative acts. Further, the level of transactivity appeared not to predict the adoption of deep-level metacognitive regulation, given that representational and operational transactive discussions were both comparably correlated with a deep-level regulation approach. The rather low frequency of occurrence of deep-level regulation might have prevented the identification of differential correlations for operational and representational transactive discussions. Given that transactivity is developmental (Berkowitz et al., 2008), the RPT-intervention might also have been too short for RPT-groups to develop towards highly transactive peer discussions. The occurrence of operational discussions might moreover have been insufficient to advance RPT-groups' deep-level regulation. An evolution towards more frequent operational transactive discussions might therefore require a longer RPT-intervention, allowing students to practice and evolve towards highly interactive discussions, as well as direct stimulation of RPT-participants to elaboratively operate on each other's reasoning, for example by including explicit scaffolds in the RPT-learning materials.

Limitations of the present study and suggestions for future research

Although the present study adds to the research on collaborative learners' regulation behaviour, its limitations should also be acknowledged. First, it reflects some methodological constraints, related to the study setting and the adopted coding strategy. Since the research was conducted in a specific collaborative learning setting with a rather small sample of RPT-groups, its findings might not be representative for students' regulation in other settings. It remains nevertheless a methodological challenge for future research to compromise on the time-consuming nature of coding dialogue data and studying larger, more representative samples (Vauras & Volet, 2013). Further, all measurements in the present study were exclusively based on students' verbalisations. It can be assumed, however, that not all of RPT-participants' reasoning was articulated, implying our measurements might not have been exhaustive for all processing, communicative, and metacognitive utterances (Iiskala et al., 2011; Perry & Winne, 2013). Additional coding of non-verbal communication and data triangulation by means of stimulated recall interviews, allowing students to clarify their behaviour, might therefore be advisable for future research.

Second, given that peer interactions are partially determined by the collaborative learning setting (Barron, 2003; Roscoe & Chi, 2008), future studies in different PT-formats or other collaborative learning settings (e.g. different age, group size, tasks, etc.) would be interesting. Cross-age or cross-ability peer tutors might model metacognitive regulation more frequently (Duran & Monereo, 2005) and be awarded higher social status due to their age and experience (Robinson et al., 2005). This might prevent tutees from challenging the tutor, hampering transactive discussions. Additionally, although active participation might be higher in dyads or triads compared to larger groups (Noroozi et al., 2013), the latter might evoke more transactive discussions given the enhanced communicative input of multiple peers. Research on different age groups would also be relevant, since learners' regulation enhances with age and operant transactive discussions increase as stages of formal thinking increase (Berkowitz et al., 2008). Further, it should be acknowledged that the design of the RPT-assignments might have been more decisive for RPT-groups' engagement in metacognitive regulation, compared to their content processing or transactive discussions (Perry & Winne, 2013; Teasley, 1997). Future research with different types of tasks is needed to rule out this possibility.

Third, the present study did not include measures of learner characteristics, although they might have partly determined collaborative learners' interactions and regulation (Barron, 2003; Webb et al., 2006). Assessing for example students' self-efficacy, motivational beliefs, and academic achievement (Iiskala et al., 2011; Pintrich, 2003; Roscoe & Chi, 2008) in future studies might provide a more complete picture of the relation between RPT-groups' regulation and their content processing and transactive discussions. Similarly, the possible influence of group-related aspects should be acknowledged in future research. Positive socio-emotional peer interactions (e.g. active listening, supportive help-giving, group cohesion) might for example facilitate transactive discussions, as well as sharing and processing knowledge, whereas negative socio-emotional interactions might rather be hampering (Rogat & Linnenbrink-Garcia, 2011; Volet et al., 2009).

Conclusion

The present study investigated how higher education RPT-groups' metacognitive regulation (i.e. orientation, planning, monitoring, evaluation, and a deep-level regulation approach) is correlated with their content processing (i.e. questioning and explaining) and the level of transactivity in their discussions. The results indicated that monitoring was strongly associated with questioning and explaining, whereas orientation and evaluation were only significantly correlated with explaining. No significant associations were found for planning. Deep-level regulation (i.e. orientation and monitoring) was significantly correlated with higher-order content processing. Additionally, both cognitively-oriented and metacognitively-oriented transactive discussions showed a significant and comparable correlation with orientation and monitoring. The deep-level approach to both regulation skills is furthermore significantly associated with both representational and operational transactive discussions.

By analysing collaborative learners' metacognitive regulation through direct observation of their diversified regulation behaviour in a process-oriented way, the present study contributes to both the metacognition and PT-research. Portraying diverse processes during collaborative learning and relating them to students' differential involvement in specific regulation skills and approaches extends prior research and enhances our understanding of collaborative learners' regulation behaviour. Additionally, it provides educators with valuable insights on how to support students' engagement in metacognitive regulation. Insight in how the adoption of particular regulation skills or approaches can be facilitated, might encourage educators to purposefully scaffold and optimise students' metacognitive regulation (e.g. designing learning environments and assignments which stimulate transactive discussions and higher-order content processing). Further, video-based research on RPT-groups' conceptual and regulative interactions advances prior studies on PT, which dominantly investigated the effects of diverse PT-formats. The present study contributes to the process-oriented PT-research, aiming to clarify why and how PT-settings are effective.

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Appendix A Examples of statement coding and interaction coding

transactivity (interaction coding)	excerpt from a RPT-discussion (RPT-session on the theme ‘peer assessment’)	metacognitive regulation/content processing (statement coding)
	T: “During peer assessment students correct each other and construct their own knowledge. So the statement seems incorrect because behaviourism is not about active knowledge construction.”	CON_knowledge-telling explanation
	t1: “Does that mean peer assessment never occurs in behaviourism?”	CON_factual question
	Because you can also give students criteria to correct each other’s work. Then peer assessment becomes more structured, more behaviouristic, not so?”	MCR_monitoring (of comprehension)
	t2: “Yeah … behaviourism promotes structured learning materials, right?”	MCR_monitoring (of comprehension)
	t3: “And the teacher should be controlling, or not?”	MCR_monitoring (of comprehension)
	t1: “I guess. But structuring also allows students to make few mistakes and that was also behaviouristic. Or am I confusing with something else?	MCR_monitoring (of comprehension)
	t4: “No I think you are right. Behaviouristic learners make few mistakes so that undesirable learning should not be undone, not so?”	MCR_monitoring (of comprehension)
	T: “It is correct that behaviourism promotes structured learning materials because students should not make incorrect interpretations.	CON_knowledge-telling explanation
	But in the statement, peer assessment is not limited to the learning outcomes because also the learning process is included. And what do you still remember about behaviourism and the learning process?”	MCR_orientation (prior knowledge activation)
	t3: “The learning process is a black box! Behaviourists focus on observable learning outcomes.”	MCR_orientation (prior knowledge activation)
	t2: “Yes! Interested in marking outcomes, not in the thinking that led to those outcomes.”	MCR_orientation (prior knowledge activation)

t5: "Is that also about the teacher as guiding practitioner?"	CON_thought-provoking question
t3: "What is a guiding practitioner?"	CON_factual question
t2: "I don't think so. I remember the guiding practitioner was from constructivism, right?"	MCR_orientation (prior knowledge activation)
t3: "Yes! Guiding as in gradually handling responsibility to students. I remember! Certainly not behaviouristic."	MCR_orientation (prior knowledge activation)
t1: "Now let's focus on the task (...) the second statement is incorrect, no doubt!	Other_task execution
t5: "I think it's important to stick to the statements and not to add information or start assuming, like we did with the idea of structuring peer evaluation. We should focus on the instructions."	MCR_monitoring (of progress)
T: "I agree we have to keep that in mind. What have we written so far in our answer? Can you read it please?"	MCR_monitoring (of progress)
t4: "I typed that the statement is incorrect, behaviourism is not about active knowledge construction neither focusses on the learning process. And those are two elements that characterise peer assessment."	Other_task execution
t1: "I think that is enough because we provided an answer and we motivated our answer, just like they asked us to do."	MCR_monitoring (of progress)

Note: T= tutor; t= tutee; MCR= metacognitive regulation; CON= content processing

representational cognitively-oriented transactive discussion

operational cognitively-oriented transactive discussion

representational metacognitively-oriented transactive discussion

operational metacognitively-oriented transactive discussion

It should be noted that statements of content processing and statements of metacognitive comprehension monitoring were sometimes closely related to each other. When students explicitly verbalised that they were checking and controlling their comprehension (e.g. "Is that correct? Not so? Am I right? Do I interpret that correctly?"), statements in this respect were coded as metacognitive comprehension monitoring. When such explication was absent, questions and explanations concerning the learning content, were coded as statements representing content processing strategies.

9

Socially shared metacognitive regulation during reciprocal peer tutoring: Identifying its relationship with students' content processing and transactive discussions

This chapter is based on:

De Backer, L., Van Keer, H., & Valcke, M. (2015). Socially shared metacognitive regulation during reciprocal peer tutoring: Identifying its relationship with students' content processing and transactive discussions *Instructional Science, 43*, 323-344.

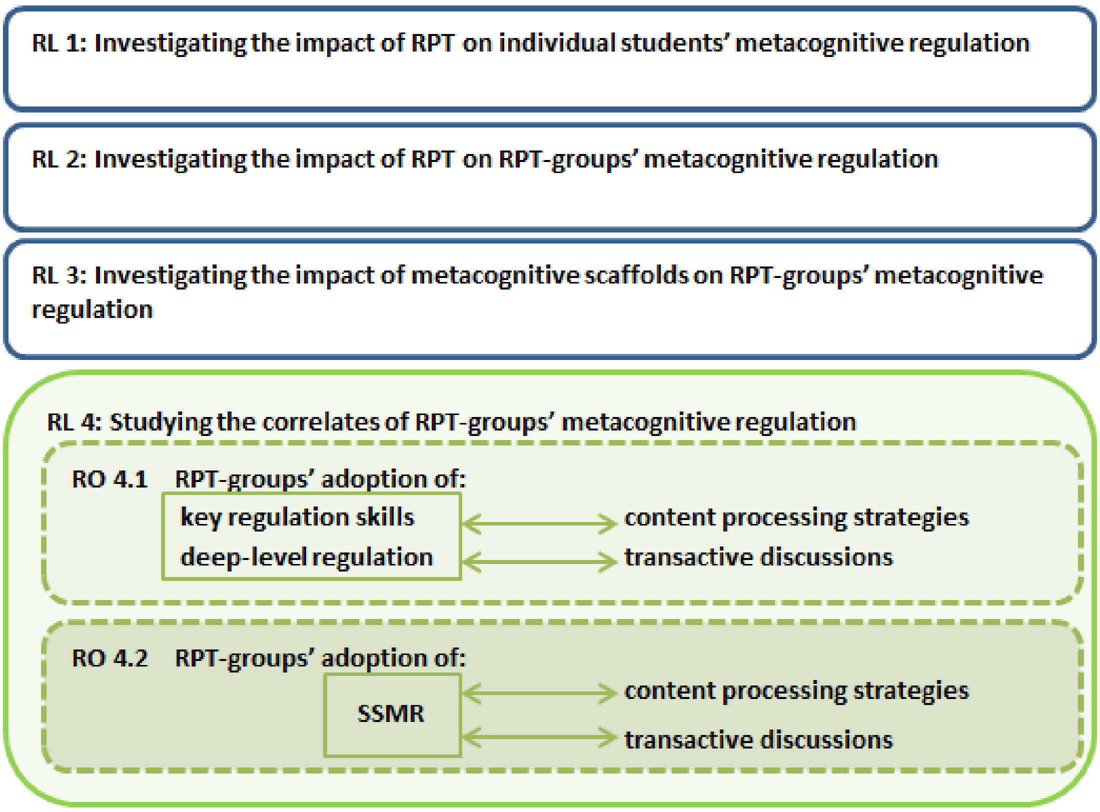

Figure 1. Chapter 9 in relation to the research lines of the dissertation

Chapter 9

Socially shared metacognitive regulation during reciprocal peer tutoring: Identifying its relationship with students' content processing and transactive discussions

Abstract

Although successful collaborative learning requires socially shared metacognitive regulation (SSMR) of the learning process among multiple students, empirical research on SSMR is limited. The present study contributes to the emerging research on SSMR by examining its correlation with both collaborative learners' content processing strategies and the level of transactivity in their discussions. The study is, more specifically, conducted in an authentic higher education reciprocal peer tutoring (RPT) setting. All sessions of a semester-long RPT-intervention of five randomly selected RPT-groups were videotaped (70h of video recordings). Literature-based coding instruments were developed to analyse RPT-groups' SSMR, content processing strategies (i.e. questioning and explaining), cognitively-oriented and metacognitively-oriented transactive discussions. In order to examine how RPT-groups' SSMR is related to their content processing and transactive discussions, binary logistic regression analyses were conducted. The results indicate that both questioning and explaining are positively associated with SSMR. Especially higher-order content processing shows a strong relationship. Further, both cognitively-oriented and metacognitively-oriented transactive discussions significantly increase the probability of RPT-groups engaging in SSMR. More specifically, transactive discussions in which RPT-participants elaboratively operate on each other's metacognitive regulation appear to be conducive. In contrast, non-transactive discussions are not significantly associated with SSMR.

Introduction

Collaborative learning is assumed to facilitate the adoption of metacognitive regulation, since it prompts students to engage in collective goal setting, to control their own and each other's comprehension, and to check collaboratively on learning strategies and outcomes (Hadwin, Miller, & Järvelä, 2011; Hurme, Palonen, & Järvelä, 2006; Volet, Vauras, & Salonen, 2009b). Collaborative learning groups also represent unique social systems, eliciting metacognitive regulation at different levels of social interaction (Iiskala, Vauras, Lehtinen, & Salonen, 2011; Järvelä, Järvenojä, Malmberg, & Hadwin, 2013). Despite taking part in a social activity, students might, for example, exclusively regulate their personal learning, considering collaborating peers merely as inspirational metacognitive models (Grau & Whitebread, 2012; Hadwin et al., 2011). On the other hand, collaborative learning might also encourage multiple students to jointly regulate the group's learning process towards shared learning objectives (Iiskala et al., 2011; Rogat & Linnenbrink-Garcia, 2011; Volet, Summers, & Thurman, 2009a). Such socially shared metacognitive regulation (SSMR) is considered the most profound mode of regulation and contributes to the quality of collaborative learning (Hadwin et al., 2011; Vauras & Volet, 2013).

Despite growing consensus on the importance of SSMR, empirical research in this respect is still emerging (Vauras & Volet, 2013). Prior studies mainly focussed on validating the differentiation between self and social forms of regulation (e.g. Grau & Whitebread, 2012; Iiskala et al., 2011; Volet et al., 2009a) or on unravelling methodological challenges when identifying SSMR in authentic environments (e.g. Perry & Winne, 2013; Vauras & Volet, 2013). Little is known, however, about the adoption of SSMR during particular learning activities, neither about which characteristics of collaborative learning and interaction facilitate or hamper peers' SSMR. The present study aims to extend prior research by identifying the correlates of SSMR in higher education reciprocal peer tutoring (RPT) groups. More specifically, the relation with RPT-groups' content processing on the one hand, the level of transactivity in their discussions on the other hand, is examined. By unravelling the correlates of SSMR, the present study not only offers concrete cues to optimise collaborative learners' SSMR, but adds valuable insights to the metacognition literature as well, advancing our understanding of SSMR (Volet et al., 2009b).

Theoretical underpinnings

Individual and socially-shared metacognitive regulation

Metacognitive regulation refers to regulatory skills and strategies used by learners to control, coordinate, and regulate their personal, a collaborating peer's, or the group's learning process (Hadwin et al., 2011; Meijer, Veenman, & van Hout-Wolters, 2006). We distinguish between orienting, planning, monitoring, and evaluating as key regulation skills (Brown, 1987; De Backer, Van Keer, & Valcke, 2012; Veenman, Elshout, & Meijer, 1997). When orienting, collaborative learners engage in task analysis and prior knowledge activation, to get acquainted with both learning objectives and each other's initial understanding (Butler, 2002). Planning encompasses selecting and sequencing problem solving strategies and developing action plans to tackle the group assignment (Meijer et al., 2006). Monitoring involves the quality control of the collaborative problem solving process, aimed at identifying inconsistencies and at optimising task execution (Meijer et al., 2006; Webb, 2009). It can be directed at students' comprehension, progress, or collaboration (Hurme et al., 2006; King, 1998; Veenman et al., 1997). Evaluation involves learners' self-judgements upon completion of collaborative learning, focussed on learning outcomes, the problem solving process, or group members' collaboration (Butler, 2002; Meijer et al., 2006).

Metacognitive regulation has traditionally been conceptualised from an individual perspective (Hadwin et al., 2011; Iiskala et al., 2011). However, with collaborative learning taking a central place in educational research, metacognition literature increasingly considers the social context in which learners apply metacognitive regulation (Vauras & Volet, 2013; Volet et al., 2009b). Collaborative learners have to discuss and agree upon “what” and “how” they will learn, experiencing the need to regulate their interactions and learning (Goos, Galbraith, & Renshaw, 2002; Hurme et al., 2006). Frequent regulative practice moreover refines and optimises students’ metacognitive regulation (Schraw, Crippen, & Hartley, 2006; Schunk & Zimmerman, 2007). Apart from being a facilitative learning environment to foster metacognitive regulation, a collaborative learning group also represents a social system, which is not equal to multiple self-oriented agents and therefore elicits regulation at various levels of social interaction (Iiskala et al., 2011; Volet et al., 2009b).

Although collaborating with peers, students might primarily adopt regulation skills to optimise their personal understanding and progress (Grau & Whitebread, 2011; Hadwin et al., 2011). During such individually-oriented metacognitive regulation, collaborating peers are merely approached as metacognitive models who might be inspirational to fine-tune one’s personal regulation skills. Collaborative learning might, however, also evoke regulative actions in which two or more peers participate (Grau & Whitebread, 2012; Perry & Winne, 2013). Depending on the level of reciprocity within those joint regulation activities, (asymmetrical) metacognitive co-regulation and (mutual) socially shared metacognitive regulation are distinguished (Iiskala et al., 2011; Järvenojä et al., 2013; Volet et al., 2009b). Metacognitive co-regulation is characterised by one peer directly instructing, scaffolding, or prompting collaborating peers into metacognitive regulation (Grau & Whitebread, 2012; Järvelä et al., 2013). During metacognitive co-regulation, regulative acts are guided by intra-individual learning goals but directed at another peer’s metacognitive activity (Volet et al., 2009b). Successful collaborative learning requires nevertheless socially shared metacognitive regulation (SSMR) at the interpersonal level (Hadwin et al., 2011; Järvelä et al., 2013). SSMR concerns a collectively assumed responsibility for metacognitive regulation among multiple collaborative learners (Iiskala et al., 2011; Grau & Whitebread, 2012; Rogat & Linnenbrink-Garcia, 2011). Although initiated by individual students’ metacognitive acts, SSMR is characterised by a subsequent involvement in metacognitive regulation of collaborating peers reciprocally operating on each other’s regulative acts. It is applied when students discuss and agree upon learning objectives, mutually monitor each other’s comprehension and the group’s progress, and collaboratively reflect upon their collaboration and learning outcomes (Järvelä et al., 2013; Perry & Winne, 2013; Volet et al., 2009b). SSMR is directed by a collectively negotiated understanding of group-level activities and demonstrated by students mutually reacting on each other’s regulative activities in a spiral-like process (i.e. one student’s regulative acts are referred to in another student’s regulative acts, which elicit subsequent regulative acts from a third student involved in the same regulation skill, who’s regulative acts refer to both the first and the second student’s contributions and in their turn elicit reciprocal regulative acts from (yet) another student, etc.). Such interdependent and reciprocal regulation of joint learning activities at the group level requires shared metacognitive awareness, which can be established by discussing the metacognitive regulation behaviour demonstrated during collaborative learning, by eliciting confirmative or corrective feedback, and by reflections on one's own regulative acts as well as on regulating the group's learning (Hadwin et al., 2011; Volet, Vauras, Khosa, & Iiskala, 2013).

There is growing consensus that successful collaboration is related to learners' coordinated and mutual engagement in regulating the group's problem solving (Iiskala et al., 2011; Lajoie & Lu, 2012; Volet et al., 2009a). Adopting SSMR results in better group performance (Chan, 2012; Järvelä et al., 2013), as well as in increased reflection on and understanding of individual students' mental models and problem solving strategies (Chan, 2012; Iiskala et al., 2011; Lajoie & Lu, 2012). By promoting reflection, SSMR can enhance students' ability to effectively self-regulate their personal learning, benefitting their academic performance (DiDonato, 2013). Applying SSMR in combination with learning domain-specific knowledge, moreover positively influences individual students' learning outcomes (Chan, 2012; Saab, van Joolingen, & van Hout-Wolters, 2012).

Peer tutoring as a fruitful environment for SSMR

Providing students with interactive learning tools and activating learning environments can facilitate their adoption of SSMR (Lajoie & Lu, 2012). The present study therefore aims at examining SSMR during reciprocal peer tutoring.

Peer tutoring (PT) is characterised by active academic helping and supporting between peers in small groups or student pairs (Falchikov, 2001; Topping, 2005). One peer, the tutor, takes a direct pedagogical responsibility by creating learning opportunities through questioning, clarifying, and active scaffolding (Duran & Monereo, 2005; Roscoe & Chi, 2008). The students being cognitively challenged by this tutor, are called tutees. Reciprocal peer tutoring (RPT) in particular, is characterised by the structured exchange of the tutor role among peers in the PT-pair/group (Duran & Monereo, 2005) and enables each student to experience the benefits of proving and receiving academic guidance (Falchikov, 2001; Topping, 2005).

The open learning environment established in a PT-setting invites students to take responsibility for their own and their peers' learning, including metacognitively regulating the collaborative learning process. Although tutors often tend to dominate the tutorial process by modelling and directly instructing tutees into content processing or metacognitive regulation (De Smet, Van Keer, & Valcke, 2009; Roscoe & Chi, 2008), their pedagogical responsibility should not necessarily hamper SSMR. Whereas the peer tutor initially acts as a model, initiating and controlling tutees' learning and the group's regulation, his academic support is expected to evolve towards coaching behaviour, as tutees gain more competence in the PT-setting (De Smet et al., 2009; Rasku-Puttonen, Eteläpelto, Arvaja, & Häkkinen, 2003). A coaching peer tutor indirectly prompts tutees' learning and guides their knowledge construction while tutees start to initiate the tutorial discussions and metacognitive regulation becomes more a shared responsibility among tutor and tutees (Pata, Sarapuu, & Lehtinen, 2005; Rasku-Puttonen et al., 2003). Although the evolution from modelling to coaching does not automatically result in SSMR, it does create a space for multiple students to mutually regulate the collaborative learning process. It should be noted, however, that the evolving dynamics between tutors and tutees alone cannot guarantee students' engagement in SSMR. Rather, it could be assumed that both group dynamics and characteristics of the collaborative learning process equally influence the opportunities to adopt SSMR (Volet et al., 2009a). The present study aims at enhancing our understanding in this respect by investigating the relation between RPT-groups' SSMR and their content processing on the one hand, the level of transactivity in their discussions on the other hand.

Content processing strategies

Questioning and explaining are fundamental sources for content processing and knowledge (co-) construction in PT-settings (Graesser & Person, 1994; King, Staffieri, & Adelgais, 1998; Roscoe & Chi, 2008; Webb, Ing, Kersting, & Nemer, 2006). Tutorial dialogues are frequently characterised by peer tutors providing explanations to convey knowledge and to make information comprehensible (Roscoe & Chi, 2008) or to correct tutees' misconceptions (Webb, 2009). Similarly, tutees often engage in self-explanations, aimed at receiving confirmative or corrective feedback from the PT-group (Chi, Siler, Jeong, Yamauchi, & Hausmann, 2001; Webb et al., 2006). Additionally, peer tutors ask questions to guide and assess tutees' understanding and to inquire about the PT-group's progress (Graesser & Person, 1994; King et al., 1998; Roscoe & Chi, 2008), whereas tutees ask for clarification after conceptual confusion, for additional information when integrating new and prior knowledge, and for evaluation of interpretations or proposed problem solving actions (Chi et al., 2001; King et al., 1998; Webb et al., 2006).

Given that questioning and explaining elicit the mutual exchange of ideas, invoking cognitive restructuring and metacognitive control of one's own and each other's learning, both content processing strategies provide students with a platform to adopt, train, and refine their metacognitive regulation skills (King, 1998; Rogat & Linnenbrink-Garcia, 2011). Volet et al. (2009a) moreover identified students' questions and explanations as triggers for collaborative learners' collective engagement in metacognitive regulation. More specifically, higher-order content processing strategies such as thought-provoking questioning or knowledge-building explaining – aimed at integrating, justifying, and elaborating on knowledge components (Graesser & Person, 1994; King et al., 1998; Roscoe & Chi, 2008) – appeared to stimulate students to adopt SSMR (Iiskala et al., 2011; Volet et al., 2009a). By causing (meta)cognitive conflicts, necessitating the revision of initial mental models and problem solving strategies, higher-order content processing might directly encourage students into joint discussions to regulate the group's learning at the interpersonal level (Rogat & Linnenbrink-Garcia, 2011; Roscoe & Chi, 2008). On the other hand, lower-order content processing – characterised by asking factual questions and providing knowledge-telling explanations (Chi et al., 2001; Graesser & Person, 1994; King et al., 1998; Roscoe & Chi, 2008) – might invite students less to reciprocally contribute to the cognitive and metacognitive discussions, possibly undermining their SSMR. Although it seems plausible that collaborative learners' content processing strategies and SSMR are connected, little empirical evidence is available.

Transactive peer discussions

Since SSMR is characterised by an interdependent, spiral-like adoption of metacognitive regulation by multiple collaborative learners (Iiskala et al., 2011; Volet et al., 2009b), it could be assumed that the intensity of peer interactions' reciprocal nature might be conducive for students' opportunities to engage in SSMR (Rogat & Linnenbrink-Garcia, 2011). The extent to which an individual student's metacognitive act evolves from a solo event to SSMR depends on whether the initial metacognitive trigger elicits additional metacognitive contributions from other students (Volet et al., 2013). In the present study, we refer to students' mutual contributions to the RPT-interactions as transactive discussions (King, 1998; Noroozi, Teasley, Biemans, Weinberger, & Mulder, 2013). Transactivity is more specifically conceptualised as a conversational mode in which students' statements operate on previously expressed reasoning of each other *(other-oriented)* or themselves *(self-oriented)* (Berkowitz, Althof, Turner, & Bloch, 2008; Teasley, 1997). Representational transactive discussions, in which students' contributions merely represent previously articulated statements, appear to hamper learning (Webb et al., 2006; Weinberger, Stegmann, & Fischer, 2007). In contrast, operational transactive discussions, characterised by conversational connectedness and elaborative transformation of peers' thinking, are positively correlated to students' reasoning and active knowledge construction (Berkowitz et al., 2008; Teasley, 1997; Webb, 2009; Weinberger et al., 2007). Goos et al. (2002) moreover directly related highly-interactive or operational transactive discussions to collaborating peers' involvement in metacognitive regulation. They found that the proportion of transactive discussions between collaborative learners was beneficial for successful collaborative problem solving, due to students' enhanced monitoring of each other's thinking.

Since collaborative learners are responsible for shaping their learning activities, as well as for metacognitively regulating the collaborative learning process, their transactive discussions can be centred around both cognitive and metacognitive discourse (Hurme et al., 2006; Goos et al., 2002; King, 1998). It seems plausible that particularly operational transactive discussions with a direct focus on metacognitive discourse can facilitate the adoption of SSMR, given their potential to elicit feedback and reflections on one's personal, another peer's, or the group's regulative actions, which might in its turn evoke joint regulative acts (Hadwin et al., 2011; Iiskala et al., 2011; Volet et al., 2009b). Nevertheless, to our knowledge, the relation between SSMR and transactive discussions has only been limitedly investigated.

Aim of the present study

Since interactive learning environments can stimulate the adoption of a socially shared regulation focus (Lajoie & Lu, 2012), the present study investigates SSMR in higher education RPT-groups. It more specifically aims at enhancing our understanding of stimulating and hampering factors affecting collaborative learners' involvement in SSMR, by studying the relation between RPT-groups' SSMR and their content processing strategies on the one hand, their transactive discussions on the other hand. The following research questions are put forward:

(1) What is the relation between RPT-groups' SSMR and (a) their adoption of content processing strategies (i.e. questioning and explaining); (b) their lower-order versus higher-order content processing strategies?

(2) What is the relation between RPT-groups' SSMR and (a) the occurrence of cognitively-oriented and metacognitively-oriented transactive discussions; (b) the representational versus operational nature of their cognitively-oriented and metacognitively-oriented discussions?

Method

Participants and setting

Sixty-four first-year Educational Sciences students who already obtained a Professional Bachelor degree (12.5% males and 87.5% females, with a mean age of 21) participated in a RPT-intervention. They were randomly assigned to eleven RPT-groups. The RPT-intervention was a formal component of students' 5-credit course "Instructional Sciences", which combines theoretical lectures with practical group work. The past four years, practical group assignments were organised through RPT. The RPT-intervention focussed on deepening students' understanding of learning contents which were previously addressed in theoretical lectures. Neither the structure and content of the course "Instructional Science", nor students' collaborative learning processes during RPT, were manipulated by the researchers when conducting the present study. The RPT-intervention followed the regular order of the theoretical lectures and RPT-groups' collaborative learning was studied as it spontaneously unfolded during RPT, implying that the present study was conducted in a naturalistic university setting.

RPT-intervention

The RPT-intervention consisted of eight successive face-to-face sessions (including a training session) of two hours each. Students tutored each other in fixed groups of six (one tutor and five tutees)[1]. The tutor role was randomly assigned to students by a university staff member and was interchanged at each session within each RPT-group. During each RPT-session, the tutor was primarily responsible for managing the interactions and stimulating collaborative learning, whereas tutees were occupied with solving the group assignment. As a manipulation check, all RPT-groups were observed weekly, to control whether tutors and tutees enacted their roles adequately.

[1] Since 64 students participated in the study, nine groups of six students and two groups of five students were formed. The data for this particular study were collected from RPT-groups consisting of six students.

Assignments

During each RPT-session, students worked on authentic group assignments, linked to themes in the course "Instructional Sciences" (see De Backer et al., 2012). The assignments were presented as open-ended tasks requiring students' collaboration and high levels of cognitive processing. Each assignment consisted of an outline of learning objectives; a subtask to get familiar with theme-specific terminology; and a subtask to apply theory to real-life cases.

Training

Students participated in a compulsory tutor training, one week before the onset of the RPT-intervention. During this training, they were informed about the multidimensional responsibilities of the peer tutor and were taught a mix of generic tutoring skills. The focus was more specifically on establishing a safe learning climate (Barron, 2003; Falchikov, 2001); managing and stimulating interactions (Chi et al., 2001; Webb, 2009); asking differentiated questions (Graesser & Person, 1994; King, 1998); giving constructive feedback (Webb et al., 2006); providing comprehensive explanations (Roscoe & Chi, 2008), and scaffolding tutees' learning (Chi et al., 2001; Molenaar, 2011). The tutor training was summarised in a manual.

Tutor guide

To prepare themselves, peer tutors received a session-specific "tutor guide" one week in advance. This offered additional information about the theory to focus upon in the RPT-session, for the PT-literature stresses the necessity of a difference in peer tutors' and tutees' domain-specific knowledge (e.g. Falchikov, 2001; Topping, 2005). Additionally, the tutor guide inspired students to tackle the problem solving process stepwise, by offering examples to explore task demands, develop actions plans, verify whether task requirements are met, and reflect on the RPT-session. These problem solving steps were depicted in a schematic overview, provided to each tutor.

Interim support

To provide support to students, both an interim supervision session (taking two hours) and two-weekly feedback sessions (each taking 30 minutes) were organised. The supervision session was set up in small groups of twelve students (recruited from two RPT-groups) and directed by a staff member, who encouraged students to reflect on their behaviour as tutor and tutee. Additionally, the staff member provided group-specific feedback every two weeks, focusing on group dynamics, peer collaboration, equal contribution of tutees, and students' tutoring approach. The feedback resulted in group reflections and action plans to optimise peer collaboration.

Data collection

All RPT-sessions of five randomly selected RPT-groups were videotaped (70h of video recordings)[2]. The video data provided real-time information about tutors' and tutees' learning activities, including the metacognitive regulation of individual participants' and the group's learning.

Coding instruments

To examine students' learning and metacognitive regulation in the RPT-groups, diverse coding instruments were designed, addressing the variables in the abovementioned research questions. First, utterances of metacognitive regulation were identified using the RPT_MCR instrument (i.e. RPT-groups' metacognitive regulation; De Backer, Van Keer, & Valcke, 2014), which incorporates literature on both metacognitive regulation (e.g. Meijer et al., 2006; Veenman et al., 1997) and tutoring/peer interactions (e.g. King, 1998; Roscoe & Chi, 2008; Webb et al., 2006). The instrument represents a multi-layered model of metacognitive regulation in collaborative settings. Orientation, planning, monitoring, and evaluation are adopted as the main coding categories and specified with sub-coding categories (i.e. task analysis, activating prior knowledge, task perceptions, planning in advance, interim planning, monitoring of comprehension, monitoring of progress, monitoring of collaboration, evaluation of learning outcomes, evaluation of the learning process, and evaluation of collaboration). Additionally, a literature-based dimension on SSMR is included (e.g. Hadwin et al., 2011; Iiskala et al., 2011; Volet et al., 2013), based on the regulative agents involved in metacognitive utterances and the reciprocity of their regulative actions. The present study conceptualises SSMR as interdependent regulative actions at the group level, demonstrated by a joint and reciprocal involvement of multiple (i.e. at least three) students in a particular regulation skill or strategy.

Second, the coding instrument RPT_CON (i.e. RPT-groups' content processing, De Backer et al., 2014) was developed to capture students' content processing strategies. Questioning and explaining served as the main coding categories. Questioning is defined as an interrogative statement in which a student requests information (Roscoe & Chi, 2008). We further distinguish factual questioning (i.e. lower-order knowledge-reviewing questions aimed at inquiring about facts, terminology, or information explicitly addressed previously) and thought-provoking questioning (implying higher-order processing by means of thinking, probing, and hinting inquiries that manifest elaborative reasoning and ask about information not previously mentioned) as sub-coding categories (Graesser & Person, 1994; King et al., 1998). Explaining is conceptualised as providing informative statements, aimed at conveying knowledge and making information comprehensible (Barron, 2003; Chi et al., 2001; Webb, 2009). Lower-order knowledge-telling (involving factual, paraphrasing, or unelaborated explanations) and higher-order knowledge-building (representing reflective conceptual reasoning,

[2] Due to limited infrastructure and equipment, it was not possible to collect video data on all RPT-groups. We therefore opted for a random sample of five RPT-groups.

elaborative rethinking of information, and active knowledge-construction) are distinguished as sub-coding categories (King, 1998; Roscoe & Chi, 2008; Webb, 2009).

Third, the coding instrument RPT_TRANS (i.e. RPT-groups' transactive discussions; De Backer et al, 2014) was adopted from Berkowitz et al. (2008) to code the level of transactivity in RPT-participants' interactions. The present study conceptualises transactivity as an other-oriented interactional mode at the dyadic level in which a student responds to his conversational partner's cognitively-oriented (Teasley, 1997; Webb, 2009; Weinberger et al., 2007) or metacognitively-oriented (Goos et al., 2002; Molenaar, 2011) statements to clarify, complete, or criticise the partner's cognitive/metacognitive reasoning. The instrument distinguishes representational transactive discussions (referring to transactive exchanges merely representing a peer's reasoning), operational transactive discussions (encompassing transactive exchanges transforming a peer's thinking), hybrid transactive discussions (being partly representational, partly operational, consisting of completions of peers' statements or paraphrases highlighting the inconsistency in their reasoning), and non-transactive discussions (referring to all exchanges not classified as transactive) as coding categories (Berkowitz et al., 2008).

Coding strategy

The coding procedure followed subsequent phases and was exclusively focussed on students' verbalised interaction. First, each RPT-session was divided into broad segments by means of episode coding, according to changes in the topic of discussion (Chi et al., 2001). An episode is conceptualised as a brief segment (including multiple conversational turns) of the overall interaction that was centred around one particular topic of discussion. After segmentation, each episode was labelled as metacognitive regulation, content processing, task-execution, or off-task behaviour.

Second, both metacognitive and content processing episodes were analysed further for more detailed statement coding (Roscoe & Chi, 2008). A statement (representing a single conversational turn) refers to a single thematically consistent verbalisation of a single metacognitive or content processing action by a single student. The identified metacognitive statements were coded with RPT_MCR, whereas the content processing statements were coded by means of RPT_CON. Each statement represented the multi-layered nature of the respective coding instrument: every statement received a general code (indicating the regulation skill, respectively content processing strategy it addressed) and a specific code (referring to the concretised regulation strategies, respectively lower-order versus higher-order content processing).

Third, metacognitive statements were analysed further to check the regulative agents involved, their underlying intentions, and the reciprocity of reactions following a metacognitive statement, in order to identify utterances of SSMR. SSMR-units represented sequences of reciprocal conversational turns (i.e. a sequence of mutual action-reaction exchanges among three or more RPT-participants, referring to one common regulative strategy), which were labelled after interaction coding (Roscoe & Chi, 2008). Typically, a SSMR-unit proceeded through different (i.e. at least three) RPT-participants' metacognitive statements. The start of a SSMR-unit consisted of the RPT-participant's metacognitive statement which triggered other students to join in the regulative action, whereas the end of the unit was marked by the last metacognitive statement directed at mutual engagement in a particular metacognitive regulation skill. Both the start and the end of an interactive SSMR-unit could be traced back after students' reciprocal statements as a whole indicated a socially shared metacognitive focus (Iiskala et al., 2011).

Fourth, the transactivity in RPT-groups' discussions was coded by means of interaction coding (Chi et al., 2001) of previously coded statements in the segmented metacognitive and content processing episodes. This coding focussed on the statements students articulated as a reaction to previously expressed metacognitive regulation, respectively cognitive reasoning. Transactive units therefore represented two conversational turns (i.e. an action-reaction exchange between two students) within the selected episodes (Roscoe & Chi, 2008). Only metacognitive reactions to metacognitive statements were segmented as a metacognitively-oriented transactive unit. Correspondingly, cognitively-oriented transactive units required a cognitive reaction to cognitive reasoning. After segmentation of the transactive units in the metacognitive, respectively content processing episodes, each unit was allocated a code from RPT_TRANS, indicating the level of transactivity[3]. Appendix A displays both statement and interaction coding.

Coding the video data was accomplished by two trained coders. They double-coded 25% of the recorded sessions (8781 statements). Cohen's Kappa indicates high interrater reliability for coding 'metacognitive regulation' (κ = .89) and good agreement beyond chance for coding 'SSMR' (κ = .84). The interrater reliability for coding 'questioning' (κ = .89) and 'explaining' (κ = .93), as well as for 'lower-order versus higher-order content processing' (κ = .96) was high. Similarly, high interrater reliability was reported for coding both 'cognitively-oriented' (κ = .91) and 'metacognitively-oriented transactive discussions' (κ = .88).

[3] It should be noted that a unit of SSMR differs from a unit of operational metacognitively-oriented transactivity in different ways and that a sequence of operational metacognitively-oriented transactive units does not automatically constitute a unit of SSMR. A metacognitively-oriented transactive unit is situated at the dyadic level and is comprised of an action-reaction exchange between two students (i.e. a first student metacognitively reacts to a second students' regulative act). A unit of SSMR concerns a sequence of regulative acts demonstrated by three or more students, who reciprocally react on each other's contributions. This implies that a first student's regulative act and a second student's reaction to it, refer to each other and that a third student's regulative reaction reflects both the first and the second student's regulative act. This is not necessarily applicable to a sequence of metacognitively-oriented transactive units, in which a first student's regulative act and a second student's reaction to it, cover the same regulative strategy, but a third student's regulative reaction to the second student's regulative act can start a new, non-related, regulative strategy. In the latter case, two transactive units can be distinguished but together they cannot be considered a unit of SSMR. Rather, the reciprocal nature of diverse regulative acts (i.e. whether or not all contributions in a sequence of metacognitive regulation refer to each other) is decisive for the socially shared focus of regulation strategies. Furthermore, when coding transactive units, the degree to which a reaction repeats or elaborates on an initial action is important to distinguish representational from operational transactive units. However, the representational versus operational nature of students' regulative reaction is not taken into consideration when distinguishing units of SSMR.

Data analysis

First, the frequency of occurrence of metacognitive and content processing statements, SSMR-utterances, and transactive units was calculated for each RPT-group and RPT-session. In total, 14968 metacognitive statements were identified, 397 SSMR-units, 11356 content processing statements, 6837 cognitively-oriented transactive units, and 5716 metacognitively-oriented transactive units. Second, the relationships between RPT-groups' SSMR and their content processing on the one hand, their transactive discussions on the other hand were studied over all RPT-groups and RPT-sessions by means of binary logistic regression analyses. The occurrence (i.e. occurrence versus non-occurrence) of SSMR served as binary dependent variable in each model. In a first model, the occurrence (versus non-occurrence) of questioning, explaining, cognitively-oriented versus metacognitively-oriented non-transactive discussions, and cognitively- versus metacognitively-oriented transactive discussions served as independent variables. In a second model, the occurrence (versus non-occurrence) of lower-order versus higher-order questioning/explaining and representational versus operational cognitively-oriented/metacognitively-oriented transactive discussions[4] served as independent variables. All independent variables were treated as binary. The absence of utterances regarding the abovementioned independent variables served as reference category in each model. To analyse the strength of identified significant relations, odds ratios were calculated. The significance level was set at .05.

Results

Descriptives

Before getting into detail about the relation between RPT-groups' SSMR and their content processing and transactive discussions, descriptive information is presented. Data from the RPT-sessions were clustered in three phases, to unravel evolutions from the starting (sessions 1-2), over the intermediate (sessions 3-4) to the closing (sessions 5-7) phase.

Metacognitive regulation

In general, RPT-groups are predominantly involved in cognitive activities (53.2%), aimed at problem solving and content processing, and in metacognitive regulation of these activities (43.6%). They limitedly engage in off-task discussions (3.2%). Table 1 depicts increased metacognitive regulation, more specifically orientation, evaluation, and monitoring. Although problem solving initially starts without much orientation (1.8%), RPT-groups increasingly orient themselves halfway (4.2%) and in the closing phase (5.2%). Similarly, adoption of evaluation grows from the starting

[4] Given the low frequency of occurrence, both cognitively-oriented and metacognitively-oriented hybrid transactive discussions (see Table 1) were excluded from the logistic regression analyses.

(1.4%), over the intermediate (2.8%) to the closing phase (4.3%). Table 1 shows a dominance of monitoring in all phases. Despite an increased adoption of monitoring at the intermediate and closing phase, this evolution is smaller compared to the trends in orientation and evaluation. In contrast, planning remains limited and is rather stable. Table 1 further depicts a positive evolution in RPT-groups' SSMR from the starting (1.2%) to the closing phase (3.8%). However, not all regulation skills become socially shared. SSMR is increasingly adopted during orientation and monitoring, but planning and evaluation are hardly shared (see Table 1).

Table 3. *Descripitives of RPT-groups' (socially shared) metacognitive regulation, content processing, and transactive discussions during the RPT-intervention*

	Starting phase		**Intermediate phase**		**Closing phase**	
	frequency	*%*	*frequency*	*%*	*frequency*	*%*
METACOGNITIVE REGULATION (TOTAL)	**3079**	**38.7**	**4128**	**43.1**	**7761**	**46.3**
orientation	145	1.8	402	4.2	869	5.2
planning	227	2.9	304	3.2	541	3.2
monitoring	2593	32.6	3150	32.9	5626	33.5
evaluation	114	1.4	272	2.8	723	4.3
SSMR	**36**	**1.2**	**64**	**1.5**	**297**	**3.8**
SS orientation	0	0	3	0.1	36	0.5
SS planning	0	0	2	0.1	2	0.0
SS monitoring	36	1.2	58	1.4	247	3.2
SS evaluation	0	0	1	0.0	12	0.1
CONTENT PROCESSING (TOTAL)	**2652**	**33.4**	**3250**	**33.9**	**5454**	**32.5**
questioning	**840**	**10.6**	**998**	**10.4**	**1567**	**9.3**
factual questioning (LO)	750	9.4	726	7.6	906	5.4
thought-provoking questioning (HO)	90	1.1	272	2.8	661	3.9
explaining	**1812**	**22.8**	**2252**	**23.5**	**3887**	**23.2**
knowledge-telling (LO)	1740	21.9	1928	20.1	2969	17.7
knowledge-building (HO)	72	0.9	324	3.4	918	5.5
TRANSACTIVE DISCUSSIONS (TOTAL)	**2951**	**100**	**3564**	**100**	**6038**	**100**
cognitively-oriented	**1695**	**57.2**	**2015**	**57.2**	**3127**	**51.8**
non-transactive discussion	246	8.3	223	6.3	332	5.4
transactive discussion	1449	48.9	1792	50.8	2795	46.5
representational	1381	46.8	1492	42.3	2098	34.9
hybrid	28	0.8	84	2.4	51	0.8
operational	40	1.3	216	6.1	646	10.8
metacognitively-oriented	**1256**	**42.8**	**1549**	**42.8**	**2911**	**48.2**
non-transactive discussion	362	12.3	357	10.1	554	9.2
transactive discussion	894	30.5	1195	33.8	2357	39.0
representational	833	28.4	976	27.7	1853	30.8
hybrid	40	1.4	36	1.0	23	0.3
operational	21	0.7	180	5.1	481	7.9

Note: SS= socially shared; LO= lower-order; HO= higher-order

Content processing

RPT-groups are generally more frequently involved in explaining (23.1%) than in questioning (10.1%). The occurrence of both strategies remains, however, stable (see Table 1). A different evolution pattern is revealed when taking into account lower-order versus higher-order content processing. Initially, RPT-groups almost exclusively apply lower-order content processing, but demonstrate increased adoption of thought-provoking questioning (3.9%) and knowledge-building explaining (5.5%) at the closing phase.

Transactive discussions

RPT-participants react more upon each other's previously expressed reasoning (82.7%) than they ignore peers' contributions (17.3%). RPT-groups' cognitively-oriented transactive discussions outnumber their metacognitively-oriented transactive discussions (see Table 1). Nevertheless, students increasingly engage in the latter from the starting (30.5%) to the closing phase (39.0%). Table 1 further shows increased operational transactive discussions, although representational transactive discussions remain dominant, both when cognitively-oriented and metacognitively-oriented.

The relation between RPT-groups' SSMR and their content processing strategies

The results indicate that RPT-groups' adoption of SSMR and their content processing are significantly associated . Table 2 shows that both questioning and explaining significantly increase the probability of SSMR (both $p<.001$). Both content processing strategies are, moreover, comparably associated with SSMR: the odds of SSMR are 2.45 times higher during questioning and 2.25 times higher when providing explanations.

Binary logistic regression analysis further reveals that RPT-groups' lower-order and higher-order content processing is significantly positively correlated to their SSMR (both $p<.001$). Table 3 demonstrates that especially the adoption of higher-order content processing is strongly correlated with SSMR. The odds of SSMR are 3.64 times higher when asking thought-provoking questions, whereas they are 3.67 times higher during knowledge-building explaining. Although lower-order questioning and explaining are also significantly associated with SSMR, the odds of demonstrating SSMR are remarkably lower when asking factual questions or providing knowledge-reviewing explanations (see Table 3).

Table 2. *Logistic regression estimates for RPT-groups' socially shared metacognitive regulation, based on the occurrence of content processing strategies and transactive discussions*

	Estimate	*SE*	*Wald*	*df*	*p*	*OR*	OR^{-1}	*95% CI*
content processing								
questioning	0.89	0.06	245.68	1	.000	2.45		[0.43, 0.56]
explaining	0.81	0.05	267.69	1	.000	2.25		[0.39, 0.50]
transactive discussions								
CO non-transactive discussion	-0.15	0.15	0.94	1	.333	0.85	1.18	[-0.24, 0.08]
CO transactive discussion	0.62	0.05	166.21	1	.000	1.85		[0.29, 0.40]
MO non-transactive discussion	-0.09	0.12	0.60	1	.440	0.91	1.10	[-0.18, 0.08]
MO transactive discussion	1.83	0.06	248.08	1	.000	6.23		[0.94, 1.07]

Note: OR= odds ratio; OR^{-1}= inverse odds ratio; CO= cognitively-oriented; MO= metacognitively-oriented; CI= confidence interval

The relation between RPT-groups' SSMR and their transactive discussions

Table 2 reveals a significant positive correlation between RPT-groups' SSMR and their transactive discussions. Non-transactive discussions, both cognitively-oriented and metacognitively-oriented, are not significantly related to SSMR (p=.333 and p=.440, respectively). In contrast, both cognitively-oriented and metacognitively-oriented transactive discussions significantly increase the probability of SSMR (both p<.001). However, metacognitively-oriented transactive discussions show a considerably larger association with SSMR, as compared to cognitively-oriented transactive discussions. Whereas the odds of SSMR are 1.85 times higher during RPT-groups' transactive discussions on cognitive discourse, the odds of SSMR are 6.23 times higher when RPT-participants transactively discuss their metacognitive regulation.

The results further demonstrate that both representational and operational transactive discussions are significantly positively correlated to RPT-groups' involvement in SSMR (both p<.001). The differential association of representational versus operational transacts is more specifically present in metacognitively-oriented transactive discussions (see Table 3). Whereas RPT-groups are 5.36 times more likely to adopt SSMR during representational metacognitively-oriented transactive discussions, the odds of SSMR are 10.48 times higher during operational transactive discussions, in which students elaboratively operate on each other's previously expressed metacognitive reasoning. In contrast, Table 3 reveals that both representational and operational cognitively-oriented transactive discussions increase the probability of SSMR in a more comparable way (1.60 times and 2.94 times, respectively).

Table 3. *Logistic regression estimates for RPT-groups' socially shared metacognitive regulation, based on their lower-order versus higher-order content processing and the level of transactivity in peers' discussions*

	Estimate	*SE*	*Wald*	*df*	*P*	*OR*	*95% CI*
content processing							
lower-order questioning	0.73	0.07	102.55	1	.000	2.07	[0.33, 0.48]
higher-order questioning	1.29	0.08	277.63	1	.000	3.64	[0.62, 0.80]
lower-order explaining	0.61	0.06	112.44	1	.000	1.85	[0.27, 0.40]
higher-order explaining	1.30	0.08	278.66	1	.000	3.67	[0.63, 0.80]
transactive discussions							
representational CO discussion	0.47	0.05	79.63	1	.000	1.60	[0.20, 0.31]
operational CO discussion	1.08	0.07	229.82	1	.000	2.94	[0.52, 0.67]
representational MO discussion	1.68	0.06	181.50	1	.000	5.36	[0.86, 0.99]
operational MO discussion	2.35	0.07	260.03	1	.000	10.58	[1.21, 1.37]

Note: OR= odds ratio; CO= cognitively-oriented; MO= metacognitively-oriented; CI= confidence interval

Discussion

The present study aimed at investigating how characteristics of collaborative learning processes during RPT are correlated with RPT-groups' adopting a socially shared regulation focus. More specifically, the relation with RPT-groups' content processing strategies on the one hand and transactive discussions on the other hand, was studied.

The relation between RPT-groups' SSMR and their content processing

The results of the present study revealed that RPT-groups' SSMR and content processing strategies are significantly positively correlated. Both questioning and explaining increased the probability of RPT-participants regulating at the interpersonal level to the same extent. Since questioning by one peer directly demands for explanations from another peer and these provided explanations might, in their turn, elicit additional questioning from collaborating peers (Goos et al., 2002; King, 1998; Roscoe & Chi, 2008), both content processing strategies might have encouraged students to mutually contribute to the peer discussions. Questioning and explaining are, moreover, frequently demonstrated during comprehension monitoring (King, 1998; Webb, 2009), which is a dominant regulation strategy during RPT (De Backer et al., 2014). Frequently being involved in mutually questioning and explaining one's own or peers' understanding, might have prompted multiple students to regulate their personal and each other's learning, fostering their engagement in SSMR.

Regarding RPT-groups' lower-order and higher-order content processing, our results indicated that although both lower-order and higher-order questioning and explaining are significantly positively correlated to SSMR, higher-order content processing showed a stronger association with SSMR. It could be that students' thought-provoking questions and knowledge-building explanations directly invoked cognitive restructuring and metacognitive control of individuals' or the group's learning (Barron, 2003; Hurme et al., 2006; King, 1998), encouraging peers to discuss their learning, aimed at getting feedback from each other (Schraw et al., 2006). In the process of co-constructing knowledge through such higher-order content processing, RPT-participants might have inspired each other to mutually engage in metacognitive discussions and corresponding regulative actions at the interpersonal level (Rogat & Linnenbrink-Garcia, 2011; Volet et al., 2009a). In contrast, students' knowledge-reviewing questions and knowledge-telling explanations, aimed at factual knowledge transmission might have stimulated students less into reciprocal discussions about their learning, hampering their adoption of SSMR.

Given that (higher-order) questioning and explaining positively correlate with students' engagement in SSMR, educators preferably model as well as explicitly prompt both content processing strategies when supporting collaborative learners. It is additionally advisable for them to prepare students for co-constructing knowledge and to train tutors to model higher-order content processing when they cognitively challenge their tutees (e.g. during an interactive training session in which students are taught to generate knowledge-building explanations and elaboratively inquire about each other's understanding; or by providing illustrations of higher-order questioning and explaining which might inspire students during collaborative learning).

The relation between RPT-groups' SSMR and their transactive discussions

As could be expected from the literature (e.g. Hadwin et al., 2011; Iiskala et al., 2011; Volet et al., 2009b), non-transactive discussions did not encourage RPT-participants to share the regulation process. In contrast, both cognitively-oriented and metacognitively-oriented transactive discussions revealed a significant positive correlation with SSMR. This should not be surprising, given that reacting to peers' previously expressed reasoning or regulative acts is a prerequisite for collectively sharing metacognitive regulation (Goos et al., 2002; Molenaar, 2011). It should be noted, however, that metacognitively-oriented transactive discussions were much more predictive for RPT-groups' SSMR. This implies that the adoption of SSMR is especially facilitated by reciprocal discussions in which collaborative learners directly discuss their regulative acts. Given that cognitively-oriented transactive discussions showed a much weaker (albeit positive) association with SSMR, and taking into account the positive correlation with RPT-groups' questioning and explaining, it is possible that students' content processing triggered their metacognitive awareness and initiated metacognitive regulation (King, 1998; Rogat & Linnenbrink-Garcia, 2011). However, whether the latter evolved towards SSMR after this trigger, probably depended less on the intensity of peers' succeeding cognitively-oriented discussions. This implies that content processing and corresponding cognitively-oriented transactive discussions might especially be found at the beginning of SSMR-episodes. Further research on the initiation of SSMR (Iiskala et al., 2011) is, however, needed to provide evidence for this hypothesis.

Regarding the level of transactivity, our results indicated that operational transactive discussions, in which RPT-participants elaboratively operated on each other's reasoning, showed a much stronger association with SSMR as compared to representational transactive discussions, in which peers' reactions merely represented initially expressed reasoning. The differential correlation of SSMR with these levels of transactivity was large for RPT-groups' metacognitively-oriented discussions. It could be that operational metacognitively-oriented transactive discussions caused metacognitive conflicts, stimulating reflection and revision of adopted regulation strategies (Berkowitz et al., 2008; Webb, 2009; Weinberger et al., 2007) and giving input to discuss and collectively regulate the group's learning. The RPT-setting moreover allowed for small-scaled and explicit modelling, observation, and consequently awareness of these metacognitively challenging acts, which might have invoked students' SSMR even more (Schraw et al., 2006; Schunk & Zimmerman, 2007). Merely repeating each other's regulative acts in representational metacognitively-oriented transactive discussions probably invited students less into additional contributions (Goos et al., 2002; Teasley, 1997), preventing reciprocal metacognitive discussions among multiple students and undermining their SSMR. In contrast, the representational versus operational nature of RPT-groups' cognitively-oriented transactive discussions did not reveal a strong differential association with SSMR. Both types of cognitively-oriented transactive discussions moreover elicited SSMR to a much lesser extent, as compared to representational/operational metacognitively-oriented discussions. This implies that peer discussions without a direct focus on regulative acts are not only less facilitative, their content and transactive structure are also limitedly predictive for applying SSMR.

The results provide educators with valuable insights on how to optimise collaborative learners' SSMR, stressing the need to invest time and effort in training collaborative learners to transactively contribute to conceptual peer discussions. Given the strong correlation between SSMR and (operational) metacognitively-oriented transactive discussions, it is furthermore important to stimulate collaborative learners' metacognitive awareness (e.g. through metacognitive prompts in learning materials which elicit regulative discussions among students; by training peer tutors to ask metacognitive questions which encourage tutees to regulate the group's learning), since the latter can facilitate transactive discussions on metacognitive regulation at the interpersonal level.

Limitations of the present study and suggestions for future research

Although the present study adds to the emerging SSMR-research, it reflects a number of limitations as well. First, the research was conducted in a specific collaborative learning setting, with a rather small sample of RPT-groups. Therefore, findings might not be representative for SSMR in other settings. Although generalisation of the results would require larger samples, it remains a methodological challenge to find a compromise between the time-consuming nature of coding dialogue data on diverse dimensions and investigating larger and more representative samples (Järvenojä et al., 2013; Vauras & Volet, 2013). Further, all measurements were exclusively based on students' verbalised reasoning and regulation, while it can be assumed that students do not always articulate their thinking (Volet et al., 2013). Consequently, the measurement of RPT-groups' content processing, transactivity, and SSMR was probably not exhaustive for all processing, communicative, and regulative utterances. Future research should investigate both students' verbal and non-verbal communication, especially since SSMR is often demonstrated in non-verbal interactions (Iiskala et al., 2011).

Second, given that peer interactions are partially determined by the collaborative learning setting (Barron, 2003; Roscoe & Chi, 2008), future studies in different PT-formats or other collaborative learning contexts (e.g. smaller group size) would be interesting. Although active participation might be higher in dyads and triads compared to small groups (Noroozi et al., 2013), the latter might encourage collaborative learners more into transactive discussions and SSMR, given the enhanced communicative input of multiple peers. Additionally, cross-age or cross-ability peer tutors might on the one hand model metacognitive regulation more frequently and intensively (Duran & Monereo, 2005), on the other hand be awarded higher social status due to their age or experience (Falchikov, 2001). Both might prevent tutees from transactively challenging the tutor’s contributions and rather undermine SSMR. Further, since online discussions are often short and non-reciprocal (Molenaar, 2011), computer-supported collaborative learning might also reveal differences in content processing strategies, transactive discussions, and consequently the adoption of SSMR.

Third, the present study did not include measures of learner characteristics as mediating variables, although it seems plausible that they partly determine the interactions and learning processes established during collaborative learning (Barron, 2003; Webb et al., 2006). Acknowledging for example students’ self-efficacy, motivational beliefs, ability, and academic achievement (Iiskala et al., 2011; Pintrich, 2003; Roscoe & Chi, 2008) in future studies could provide additional insight into students’ content processing, communicative, and regulative behaviour. In line with this, future research preferably also takes into account the possible influence of group-related factors. Collaborative learners’ prior relationships might for example affect their collaboration and learning (Webb et al., 2006). Additionally, it could be assumed that positive socio-emotional peer interactions (e.g. active listening, supportive help-giving, safe learning climate, group cohesion) can facilitate higher-order content processing, transactivity, and SSMR, whereas negative socio-emotional interactions might rather be hampering (Rogat & Linnenbrink-Garcia, 2011; Volet et al., 2009a).

Fourth, although the present study enhanced our understanding of RPT-groups’ SSMR, it could not capture the dynamics in peers’ interactions invoking SSMR. Combining video-based research with social network analysis could therefore be promising (Hurme et al., 2006; Järvenojä et al., 2013). Visualising the collaborative learning process could unravel how SSMR, as well as content processing strategies and transactive discussions, are shaped and supported through peers’ interactions. Additionally, social network analysis could provide measures of learning and regulation at both the individual and the group level. These would be valuable to examine the effects of SSMR on RPT-groups’ learning and individual participants’ learning outcomes in future studies (Perry & Winne, 2013; Volet el al., 2013).

Last, it seems plausible that some metacognitive behaviour can invite students more into joint regulation (e.g. shared monitoring of each other’s comprehension). It would therefore be interesting to study SSMR taking into account particular regulation skills and all cyclical phases of metacognitive regulation (Järvelä et al., 2013). Additionally, differentiating low-level from deep-level approaches to SSMR and identifying the correlates of both would be valuable future research directions (Rogat & Linnenbrink-Garcia, 2011). The low- versus deep-level approach to SSMR could for example be conceptualised based on the low/high level of regulative synergy among all collaborative learners; the hindering/facilitating impact of SSMR on the collaborative learning process; the negative/positive socio-emotional relations among students; and the low/high degree to which they operate on each other's regulative acts (Goos et al., 2002; Iiskala et al., 2011; Rogat & Linnenbrink-Garcia, 2011; Volet et al., 2009a). It would further be interesting to study whether the approach to SSMR influences the learning process during RPT and the learning outcomes (e.g. achievement, transfer of learning, understanding of the learning content, etc.) of individual RPT-participants (DiDonato, 2013; Saab et al., 2012). Such effect studies which compare RPT-groups that dominantly apply low- versus deep-level SSMR or that frequently versus limitedly adopt SSMR, could advance our understanding of the importance of SSMR for successful collaborative learning.

Conclusion

The present study unravelled some correlates of SSMR in higher education RPT-groups. More specifically, the relation between RPT-groups' SSMR and their content processing strategies (i.e. questioning and explaining) on the one hand, transactive discussions on the other hand, was examined. The results demonstrated that both questioning and explaining increased the probability of SSMR significantly. Especially higher-order content processing appeared to correlate with SSMR. Additionally, both cognitively-oriented and metacognitively-oriented transactive discussions showed a significant positive association with SSMR, although metacognitively-oriented discussions appeared more predictive in this respect. Further, operational transactive discussions reflected a stronger correlation with SSMR compared to representational discussions, especially when peers directly discussed their regulation.

Whereas prior studies mainly focussed on conceptualising and validating social forms of regulation, the present study identified some conditions facilitating the adoption of SSMR. Its innovative scope therefore adds valuable insights to an empirically underexposed domain in the metacognition research. The results not only enhance our theoretical understanding of SSMR, but offer educators direct cues to optimally scaffold and foster collaborative learners' SSMR as well. Moreover, the present study allows SSMR-scholars to advance their research, given its provided input to conduct effect studies investigating the impact of instructional interventions on students' SSMR.

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Appendix A Examples of statement and interaction coding

transactivity (interaction coding)	excerpt from a RPT-discussion (RPT-session on the theme ‘peer assessment’)	metacognitive regulation/content processing (statement coding)	SSMR (interaction coding)
	T: “During peer assessment students correct each other’s knowledge and construct their own knowledge. So the statement seems incorrect because behaviourism is not about active knowledge construction.”	CON_knowledge-telling explanation	
	t1: “Does that mean peer assessment never occurs in behaviourism?”	CON_factual question	
	Because you can also give students criteria to correct each other’s work. Then peer assessment becomes more structured, more behaviouristic, not so?”	MCR_comprehension monitoring	
	t2: “Yeah … behaviourism promotes structured learning materials, right?”	MCR_comprehension monitoring	
	t3: “And says the teacher should be controlling, or not? By structuring, could that be correct?”	MCR_comprehension monitoring	
	t1: “Structuring also allows students to make few mistakes and that was also behaviouristic.”	CON_knowledge-building explanation	
	t4: “Behaviouristic learners make few mistakes because of the structure offered, so that undesirable learning should not be undone. Reinforcing was important, not punishing.”	CON_knowledge-building explanation	
	T: “It is correct that behaviourism promotes structured learning materials because students should not make incorrect interpretations.”	CON_knowledge-telling explanation	

T: “But in the statement, peer assessment is not limited to the learning outcomes because also the learning process is included. And what do you still remember about behaviourism and the learning process?”	MCR_prior knowledge activation
t3: “Black box! The learning process is a black box. Behaviourists focus instead on observable learning outcomes.”	MCR_prior knowledge activation
t2: “Yes! Interested in marking outcomes but not in the thinking that led to those outcomes, I remember!”	MCR_prior knowledge activation
t5: “Is that also about the teacher as guiding practitioner?”	CON_thought-provoking question
t3: “What is a guiding practitioner? Does he guide to correct answers?”	CON_factual question
t2: “I don’t think so. I remember the guiding practitioner was a teacher role from constructivism. ”	MCR_activation of prior knowledge
t4: “Yes! Guiding as in gradually handling responsibility to students. Now it rings a bell!”	MCR_activation of prior knowledge
t1: “Now let’s focus on the task (...) the second statement is incorrect, no doubt!	Other_task execution
t5: “I think it’s important to stick to the statements and not to add information or start assuming, like we did with the idea of structuring peer evaluation. We should focus on the instructions.”	MCR_monitoring of progress
T: “I agree we have to keep that in mind. What have we written so far in our answer? Can you read it please?”	MCR_monitoring of progress
t4: “I typed that the statement is incorrect, behaviourism is not about active knowledge construction neither focusses on the learning process. And those are two elements that characterise peer assessment.”	Other_task execution
t1: “I think that is enough because we provided an answer and we motivated our answer, just like they asked us to do.”	MCR_monitoring of progress
T: “Just one more thing about behaviourists and assessment. We have discussed the difference between formative and summative evaluation. Summative evaluation occurs at the end of a learning cycle, while formative evaluation can be considered continuous	CON_knowledge-telling explanation

evaluation.	
Which type of evaluation do you associate with behaviourism?”	CON_thought-provoking question
t2: “Formative? Could it be?”	MCR_comprehension monitoring
t4: “No I don’t think so. I thought formative focussed more on the process of learning. Or am I interpreting things wrong? I thought behaviourstic evaluation is summative and more product directed. Could that be correct?	MCR_comprehension monitoring
T: “Why do you think? Could you explain your thinking to us?”	CON_thought-provoking question
t2: “Behaviourists are interested in the learning outcomes and outcomes are evaluated at the end of the learning process. And evaluation at the end is summative evaluation.” (...)	CON_knowledge-telling explanation
t3: “Aha, I understand your reasoning! But not all summative evulation is behaviouristic I think. Because summative self-evaluation for example would not be accepted in behaviourism. That would give too much responsibility to the students, while it is the teacher who is supposed to control and evaluate students’ learning.”	CON_knowledge-building explanation

Note: T= tutor; t= tutee; MCR= metacognitive regulation; CON= content processing; SSMR= socially shared metacognitive regulation

representational cognitively-oriented transactive discussion

operational cognitively-oriented transactive discussion

representational metacognitively-oriented transactive discussion

operational metacognitively-oriented transactive discussion

SSMR

10 General discussion and conclusion

Chapter 10
General discussion and conclusion

Abstract

The present dissertation aimed at examining whether participation in same-age reciprocal peer tutoring (RPT) generated a positive impact on higher education students' adoption of individual and socially shared metacognitive regulation. Additionally, it aimed at investigating the correlates of RPT-groups' metacognitive regulation behaviour. This final chapter provides a comprehensive discussion of the major findings revealed in the different empirical studies, presented in chapter 2 to 9. It further presents a general overview of the present dissertation's overall limitations. Additionally, based on both these limitations and recent insights on metacognitive regulation in collaborative settings, an agenda for future research is put forward. This final chapter concludes with the present dissertation's implications for theory and empirical research on the one hand, educational practice and policy on the other hand.

Introduction

Given its focus on self-management and self-directed learning, higher education requires students to apply metacognitive regulation skills (Bruinsma, 2004; Nota, Soresi, & Zimmerman, 2004). Nevertheless, higher education students' metacognitive regulation is often insufficient to adequately self-regulate their learning (MacLellan & Soden, 2006; Nota et al., 2004). Fostering students' metacognitive regulation has therefore become an important educational objective. In the first chapter of the present dissertation, we highlighted the value of collaborative learning when facilitating or optimising students' adoption of metacognitive regulation. Shared knowledge construction and collective problem solving encourage students to discuss and regulate their own and each other's learning, allowing them to practice and refine one's own metacognitive regulation based on the observed regulation behaviour of collaborating peers (Hadwin, Wozney, & Pontin, 2005; Hurme, Palonen, & Järvelä, 2006; Roscoe, 2014). Additionally, collaborative learning challenges students to share metacognitive regulation at an interpersonal level, which is assumed to advance both individual students' and the collaborative learning group's learning (Iiskala, Vauras, Lehtinen, & Salonen, 2011; Rogat & Adams-Wiggins, 2014; Volet, Summers, & Thurman, 2009a). Although the metacognitive benefits of collaborative learning are widely acknowledged, it remains unclear which underlying processes or interaction mechanisms actually evoke collaborative learners' engagement in particular metacognitive regulation behaviour, as process-oriented studies on metacognitive regulation in social settings are scarce (Khosa & Volet, 2014; Rogat & Linnenbrink-Garcia, 2011; Vauras & Volet, 2013). Unravelling the interactional dynamics between collaborative learners is, however, necessary to comprehend and optimise collaborative learning's metacognitive potential (Molenaar & Järvelä, 2014; Roscoe, 2014). The present dissertation therefore aimed at examining why same-age reciprocal peer tutoring (RPT), as a specific type of collaborative learning, is valuable to foster higher education students' adoption of metacognitive regulation, taking into account process-oriented measures of collaborative learning and regulation.

The dissertation was driven by four lines of research, directed at on the one hand studying the impact of RPT on the adoption of particular metacognitive regulation behaviour, on the other hand investigating the correlates of RPT-groups' metacognitive regulation. A first research line (RL1) focussed on studying the impact of participation in RPT on individual RPT-participants' adoption of metacognitive regulation, by assessing their metacognitive regulation prior to and upon completion of a RPT-intervention. Within this first research line, two research objectives (RO) were distinguished, namely:

- RO 1.1: studying the impact of RPT on individual students' metacognitive knowledge, perceived adoption of key regulation skills, and actual adoption of key regulation skills;
- RO 1.2: studying the impact of RPT on individual students' actual adoption of key regulation skills and deep-level approach to metacognitive regulation.

RL1 aimed at contributing to the metacognition literature by taking an integrative perspective on metacognitive regulation. It more specifically assessed students' adoption of all key regulation skills (i.e. orientation, planning, monitoring, and evaluation) and more concrete regulation strategies, and took into account differences in the quality of applied regulation skills by distinguishing low-level from deep-level regulation.

In addition to the focus on individual RPT-participants' metacognitive regulation in RL1, the second research line (RL2) investigated the impact of RPT based on group-related measures of metacognitive regulation demonstrated within RPT-groups. It more specifically studied time-bound evolutions in RPT-groups' metacognitive regulation behaviour and considered upward trends in the adoption of particular regulation skills (i.e. orientation, planning, monitoring, evaluation), approaches (i.e. low- versus deep-level regulation), and foci (i.e. individually-oriented metacognitive regulation, co-regulation, and socially shared metacognitive regulation) as a positive impact of RPT. Within the second research line, the following two research objectives were put forward:

- RO 2.1: unravelling time-bound evolutions in the frequency of occurrence of RPT-groups' adoption of key regulation skills, in their engagement in deep-level metacognitive regulation, as well as in tutees' initiative for metacognitive regulation;
- RO 2.2: unravelling time-bound evolutions in RPT-groups' adoption of individually-oriented metacognitive regulation, co-regulation, and socially shared metacognitive regulation (SSMR).

RL2 aimed at advancing our understanding of collaborative learners' adoption of metacognitive regulation through process-oriented, micro-analytical examination of RPT-groups' regulative interactions, as well as by acknowledging the temporal dynamics of metacognitive regulation.

Additionally, by investigating RPT-groups' regulative foci, in particular their SSMR, RL2 aimed at providing innovative insights to the emerging research on interpersonal metacognitive regulation.

Whereas the first and second research line intended to examine RPT's natural metacognitive potential, the third research line (RL3) studied whether providing RPT-groups with metacognitive scaffolds can optimise their naturally occurring metacognitive regulation behaviour. Within the third research line, two research objectives were distinguished, namely:

RO 3.1: investigating the impact of different scaffold types (i.e. structuring versus problematising scaffolds) on RPT-groups' adoption of key regulation skills, deep-level regulation approach, and tutee-initiated metacognitive regulation;

RO 3.2: investigating the impact of different scaffold types (i.e. structuring versus problematising scaffolds) on RPT-groups' adoption of co-regulation and SSMR.

By examining which types of scaffolds are most effective in supporting collaborative learners' adoption of and initiative for particular regulation skills and approaches, RL3 intended to contribute to the literature on metacognitive scaffolds. Additionally, RL3 aimed at extending prior research on SSMR, which is dominantly concentrated on the conceptualisation of self versus social forms of metacognitive regulation. By studying how to elicit social forms of metacognitive regulation, RL3 intended to provide innovative insights, advancing our theoretical understanding of SSMR.

Unlike the other research lines, the fourth research line (RL4) was not directed at examining RPT's metacognitive benefits. Rather, it studied the relationship between RPT-groups' adoption of particular metacognitive regulation behaviour and characteristics of peer tutors' and tutees' interactions, in order to advance our understanding of collaborative learners' metacognitive regulation in relation to the underlying dynamics of the collaborative learning process. Within the fourth research line, the following two research objectives were put forward:

RO 4.1: examining the relationship of RPT-groups' adoption of key regulation skills and deep-level regulation approach with their content processing strategies and transactive discussions;

RO 4.2: examining the relationship of RPT-groups' adoption of SSMR with their content processing strategies and transactive discussions.

By identifying the correlates of RPT-groups' metacognitive regulation, RL4 aimed at explaining the metacognitive potential of RPT. By unravelling which elements of RPT-participants' collaboration stimulate or rather hamper their adoption of key regulation skills, deep-level regulation, and in particular their socially shared regulation focus, RL4 intended to add innovative insights to an underexposed domain in the metacognition research.

In order to achieve the research objectives outlined above, eight empirical studies were conducted, as described in chapter 2 to chapter 9. In the following paragraphs, we discuss the main findings for each research line, in relation to both the research objectives and insights from previous research.

Overview and discussion of the main findings

Research line 1: Studying the impact of participation in RPT on individual students' metacognitive regulation

Although it is widely acknowledged that collaborative learning is a fruitful environment to foster students' metacognition, previous research only limitedly investigated the metacognitive benefits of peer tutoring and RPT in particular (King, Stafferie, & Adelgais, 1998; Roscoe, 2014; Shamir & Tzuriel, 2004). Prior studies moreover exclusively examined the impact of peer tutoring on students' monitoring. The first research line intended to extend prior findings and investigated the impact of participation in RPT on higher education students' metacognitive knowledge, their adoption of key regulation skills (i.e. orientation, planning, monitoring, and evaluation), as well as their involvement in low- versus deep-level metacognitive regulation. It is to be interpreted as an initial step in examining the metacognitive effectiveness of RPT. Two empirical studies, described in chapter 2 and 3, were related to the first research line.

Chapter 2 reported on a study in which 67 first-year students in the Educational Sciences programme who already obtained a Professional Bachelor degree, participated in a semester-long RPT-intervention in small groups of six students. Both before the onset and upon completion of the RPT-intervention, individual RPT-participants' metacognition was assessed by means of a self-report questionnaire (i.e. the Metacognitive Awareness Inventory – Schraw & Dennisson, 1994) and think-aloud protocol analysis (Greene, Robertson, & Croker Costa, 2011; Veenman, 2005). Self-report was used to measure students' metacognitive knowledge and self-perceived metacognitive regulation, whereas think-aloud protocol analysis was adopted to assess students' actual adoption of metacognitive regulation. Paired samples t-tests were conducted to investigate pretest-to-posttest changes in students' metacognition.

Chapter 2 revealed that students reported high estimates of both metacognitive knowledge and metacognitive regulation, at pretest as well as at posttest. No significant pretest-to-posttest change was shown for students' metacognitive knowledge, neither for their self-perceived adoption of regulation skills. Given that students' metacognitive knowledge is influenced by age-related improvements in human memory and cognition, becoming relatively stable in adult learners (Brown, 1987; Perfect & Schwartz, 2002; Schneider, 2008), it seems plausible that participation in RPT could not establish significant differences in higher education students' metacognitive knowledge. The questionnaire-based analyses did, however, confirm the critical questions raised in previous research regarding the accuracy of off-line assessment of metacognitive regulation (Azevedo, 2009; Pintrich, Wolters, & Baxter, 2000; Veenman, 2005), since comparing the self-report data with the think-aloud protocol data revealed an important discrepancy in students' perceived and actual adoption of regulation skills. Whereas students frequently applied monitoring, both at pretest and posttest, their engagement in orientation, planning, and evaluation was considerably smaller compared to their perceived use of these regulation skills. Chapter 2 further reported significant pretest-to-posttest changes in students' actual adoption of monitoring (i.e. of both comprehension and progress), orientation (i.e. task analysis), and evaluation (i.e. of learning outcomes), revealing both a more frequent and more varied use of these regulation skills at posttest. A significant pretest-to-posttest change in students' planning was, however, not found. Based on the results described in chapter 2, RPT appears to have the potential to promote students' actual metacognitive regulation behaviour. Collectively solving academic assignments during the RPT-sessions probably invited students to express and challenge their own and each other's understanding and problem solving strategies (Hurme et al., 2006; Roscoe, 2014; Volet, Vauras, & Salonen, 2009b), allowing them to practice, observe, and refine their metacognitive regulation skills (Hadwin et al., 2005; Schunk & Zimmerman, 2007). It seems plausible that semester-long experience with RPT encouraged students to internalise particular regulation skills and strategies applied during the RPT-sessions and to implement them when conducting the individual think-aloud task at posttest. Students' more varied use of orientation, monitoring, and evaluation at posttest moreover suggested the existence of quality differences in adopted regulation skills and strategies.

The study described in chapter 3 investigated the impact of RPT on individual students' metacognitive regulation, taking into account both the limitations and the findings of the study in chapter 2. More specifically, it exclusively focussed on assessing students' adoption of key regulation skills by means of think-aloud protocol analysis, given that off-line measures demonstrated to be inaccurate and RPT appeared not to be influential towards students' metacognitive knowledge. Further, it explicitly acknowledged quality differences in students' adopted regulation behaviour by investigating the impact of RPT on students' adoption of a deep-level regulation approach. Additionally, the original research design was modified into a quasi-experimental pretest-posttest design involving one experimental and two control groups. The experimental group consisted of the complete population of 64 first-year students in the Educational Sciences programme who already obtained a Professional Bachelor degree. They participated in the RPT-intervention during a complete semester. The first control group consisted of 24 freshmen in the Educational Sciences programme, whereas the second control group was comprised of 22 first-year students in the Social Welfare Studies programme of the same university faculty, who also attained a Professional Bachelor degree. None of the control groups was involved in tutoring or any comparable collaborative learning approach. At the start and the end of the research period, all participants individually performed a think-aloud task, aimed at concurrently assessing their actual metacognitive regulation behaviour (Greene et al., 2011). To study the impact of RPT on students' use of metacognitive skills and deep-level regulation, two-way mixed ANOVA's were performed.

In line with the results of chapter 2, chapter 3 revealed a significant increased adoption of monitoring (i.e. of both comprehension and progress), evaluation (i.e. of learning outcomes), and to a lesser extent orientation (i.e. task analysis) by experimental students at posttest. Except for enhanced comprehension monitoring, the abovementioned pretest-to-posttest changes were not demonstrated by students in the control groups. Also in line with the results described in chapter 2, a significant impact on students' planning behaviour was not found, nor for the experimental group, nor for control students. The finding that students' planning did not change significantly from pretest to posttest might be due to the design of the think-aloud tasks in both studies, given that task-specific characteristics of academic assignments partially determine the outcomes of protocol analysis (Greene et al., 2011; van Someren, Barnard, & Sandberg, 1993). Since students were expected to solve three thought-provoking questions on a well-structured academic task, the opportunities to plan task execution were probably scarce. Additionally, students might have not felt the need to sequence problem solving steps within the available time framework for conducting the think-aloud task, which might have limited their adoption of planning, preventing a significant change in planning after participation in RPT.

Regarding students' regulation approach, chapter 3 demonstrated a dominant use of low-level regulation for experimental and control students, both at pretest and posttest. Nevertheless, it also revealed a significant increase in deep-level metacognitive regulation for experimental students, which was not demonstrated by control students. Experimental students particularly outperformed control students in applying deep-level comprehension monitoring. Since tutors were trained to promote tutees' profound reflective thinking during RPT by asking critical questions, providing cognitive scaffolds, and giving elaborative explanations, it can be assumed that RPT-participants observed and internalised these strategies, which might have facilitated their deep-level comprehension monitoring when conducting the individual think-aloud task at posttest (King, 1998; Rogat & Linnenbrink-Garcia, 2011; Roscoe, 2014). Although experimental students additionally demonstrated significantly enhanced deep-level task analysis, monitoring of progress, and evaluation of learning outcomes at posttest, the frequency of occurrence of these deep-level regulation strategies remained low. Students' rather limited involvement in deep-level regulation might be explained by both the need for explicit metacognitive prompts (Azevedo & Hadwin, 2005; Manlove, Lazonder, & de Jong, 2007; Schunk & Zimmerman, 2007) or more extensive practice with regulation skills (Greene & Azevedo, 2007; Schraw, Crippen, & Hartley, 2006) in order to promote students' engagement in complex regulation behaviour (e.g. deep-level regulation).

In sum, based on the findings of both chapter 2 and 3, three major conclusions can be drawn. First, a mismatch between students' perceived and actual metacognitive regulation was revealed, probably hazarding productive self-regulated learning (Winne & Jamieson-Noel, 2002). Overestimation of one's metacognitive regulation generally results in persistent adoption of inadequate or mediocre regulation strategies, which might impair students' academic achievement and meaningful learning (Pintrich, 2002; Schraw & Nietfeld, 1998; Winne & Jamieson-Noel, 2002). The first research line consequently confirms the need to promote metacognitive awareness among higher education students (MacLellan & Soden, 2006; Schraw, 1998). Second, we can conclude that RPT has the potential to benefit higher education students' actual adoption of metacognitive regulation. This is an important finding given that higher education students' academic success is often hampered due to insufficient metacognitive regulation (Azevedo, 2009; Bruinsma, 2004; MacLellan & Soden, 2006; Prins, Veenman, & Elshout, 2006). It should be noted, however, that participation in RPT did not elicit a balanced adoption of diverse regulation skills. Although it generated a critical impact on (comprehension) monitoring, RPT was less influential towards students' adoption of orientation and evaluation, and had no impact on students' planning behaviour. Although it is possible that task-related characteristics particularly evoked students' monitoring and rather limited their adoption of planning during think-aloud problem solving (Perry & Winne, 2013; Pifarré & Cobos, 2010), it seems equally plausible that RPT is naturally more beneficial for eliciting monitoring. Co-constructing knowledge with peers during the RPT-sessions especially required students to reflect upon and monitor their understanding (Hurme et al., 2006; Roscoe, 2014; Volet, et al., 2009a). Consequently, students' frequent practice with monitoring during the RPT-sessions probably especially optimised their adoption of monitoring during the individual think-aloud task. On the other hand, the nature of the other key regulation skills, as well as of the cognitive activities evoking these regulation skills, might have stimulated the adoption of these regulation skills less easily when students tutored each other. Third, the first research line successfully indicated the importance of identifying and distinguishing low-level versus deep-level regulation approaches. This not only introduces a more in-depth operationalization of metacognitive regulation but also confirms the need to take into account the quality of adopted regulation skills when assessing the impact of instructional interventions aimed at optimising students' metacognitive regulation (Greene & Azevedo, 2009; Rogat & Linnenbrink-Garcia, 2011; Zimmerman & Schunk, 2011).

Research line 2: Studying the impact of RPT on RPT-groups' metacognitive regulation

The second research line aimed at enhancing our understanding of RPT's metacognitive benefits revealed in the first research line. It more specifically studied evolutions in the metacognitive regulation behaviour of RPT-groups through in-depth examination of their regulative interactions when tutoring each other. Analyses were directed at unravelling evolutions in the frequency of occurrence of RPT-groups' adopted key regulation skills, deep-level regulation, tutee-initiated regulation, and RPT-groups' adopted regulative foci. Two empirical studies, described in chapter 4 and 5, were related to this research line. In both studies, 64 first-year students in the Educational Sciences programme who already obtained a Professional Bachelor degree, participated in a semester-long RPT-intervention in small groups of six students. All RPT-sessions of five randomly-selected RPT-groups (30 students) were videotaped. Assessment of RPT-groups' metacognitive regulation was based on the observation of tutors' and tutees' verbalised interactions. Mixed models for logistic regression allowing change points were adopted to study time-bound evolutions in RPT-groups' metacognitive regulation and to identify at which specific point in time a remarkable change in their regulation behaviour occurred.

Chapter 4 revealed a significant positive evolution in RPT-groups' adoption of metacognitive regulation as the RPT-intervention progressed. The largest increases were shown for orientation (i.e.

prior knowledge activation) and evaluation (i.e. of learning outcomes and the learning process). Both evolutions were moreover demonstrated from the first half of the RPT-intervention onwards. In line with our studies on the impact of RPT on individual students' regulation (chapter 2 and 3 in RL1), a significant evolution in RPT-groups' planning was not shown. Although this results raises questions about the value of RPT for evoking and optimising collaborative learners' planning, it should be acknowledged that the RPT-assignments might have been too structured for RPT-participants to extensively plan their collective problem solving (Iiskala et al., 2011; Perry & Winne, 2013; Pifarré & Cobos, 2010). Their limited practice with planning might moreover have prevented the internalisation of modelled planning by individual students, and consequently, the elicitation of additional planning by collaborating peers (Hadwin et al., 2005; Schunk & Zimmerman, 2007). In contrast, solving a complex group assignment during a limited period of time probably required students to orient themselves sufficiently and to share prior knowledge, in order to establish a common focus during conceptual peer discussions (Barron, 2003; Chi, Siler, Jeong, Yamauchi, & Hausmann, 2001; King, 2002). Similarly, RPT might have required recurring evaluation of learning to ensure efficient problem solving with multiple students. This might explain RPT-groups' positive evolutions in orientation and evaluation.

RPT-groups' regulation behaviour remained dominantly low-level throughout the RPT-intervention. Nevertheless, significant positive evolutions were demonstrated for their adoption of deep-level orientation (through activation of prior knowledge) and deep-level comprehension monitoring, from the first half of the RPT-intervention onwards. It seems plausible that tutors' inquiries of tutees' understanding served as direct metacognitive prompts, fostering students' prior knowledge activation and deep-level comprehension monitoring. Further, both deep learning (King, 1998; Roscoe & Chi, 2007) and highly interactive discussions (Goos, Galbraith, & Renshaw, 2002; Iiskala et al., 2011) are related to collaborative learners' engagement in deep-level regulation. Both might have been particularly demonstrated when RPT-participants expressed and compared their thinking, aimed at co-constructing knowledge (e.g. when activating prior knowledge or monitoring comprehension).

Regarding the initiative for regulation, a significant positive evolution towards tutee-initiated monitoring upon completion of the RPT-intervention was revealed. On the other hand, orientation, planning, and evaluation remained dominantly initiated by the tutor. No significant trend in tutees' initiative for these regulation skills was identified. Additionally, tutees' initiative for deep-level metacognitive regulation remained limited throughout the RPT-intervention. These results appear to suggest that tutees needed longer or more intensive metacognitive modelling (Hadwin et al., 2005; Schraw et al., 2006) or explicit scaffolding (Azevedo & Hadwin, 2005; Bannert & Reimann, 2012; Molenaar, Sleegers, & van Boxtel, 2014) in order to start initiating all key regulation skills or a deep-level regulation approach. Since orientation, planning, and evaluation, as well as a deep-level regulation approach were less frequently adopted compared to (low-level) monitoring, the opportunity for peer tutors to practice and refine their modelling of this particular regulation behaviour was probably scarce, which might explain tutees' subsequent hesitation to initiate this limitedly observed regulation behaviour (Greene & Azevedo, 2007; Hadwin et al., 2005; Schunk &

Zimmerman, 2007; Webb, 2009). In contrast, tutors' frequent inquiries about tutees' understanding might have facilitated tutees' internalisation of and initiative for monitoring.

Chapter 5 studied time-bound evolutions in the regulative foci of RPT-groups. The results revealed significant positive evolutions in the adoption of tutee-prompted co-regulation and socially shared metacognitive regulation (SSMR), as well as significant negative evolutions in RPT-groups' tutor-prompted co-regulation and individually-oriented metacognitive regulation. Initially, RPT-groups' metacognitive regulation was dominantly characterised by tutor-prompted co-regulation, probably related to peer tutors operating as metacognitive models, demonstrating particular regulation behaviour and encouraging tutees to act likewise (De Smet, Van Keer, & Valcke, 2009; Rasku-Putonen, Eteläpelto, Arvaja, & Häkkinen, 2003). In comparison, both RPT-groups' tutee-prompted co-regulation and SSMR were limited in this initial phase. This finding suggests that the instructive nature of peer tutors' modelling support left limited space for tutees' regulative contributions and confirms previous findings that directive group members are rather hampering for collaborative learners' involvement in SSMR (Rogat & Linnenbrink-Garcia, 2011). As they gained more expertise in the RPT-setting, tutees progressively participated in regulating RPT-groups' learning, while tutors took a less directive role towards individual tutees' and the group's regulation. Although observation of tutors' modelled regulation behaviour might have stimulated tutees to apply and refine their personal metacognitive regulation skills (Hadwin et al., 2005; Schraw et al., 2006), our results suggested that the social and interactive nature of RPT encouraged tutees more easily to direct their enhanced regulative practice towards collaborating peers' learning (i.e. as demonstrated in RPT-groups' enhanced tutee-prompted co-regulation) instead of stimulating tutees to optimise their personal learning through individually-oriented regulative acts.

Based on the results presented in chapter 5 it can further be concluded that RPT fostered the adoption of a socially shared regulation focus. More specifically, the changes in peer tutors' support as tutees become more skilled in RPT appeared to have played an essential role in eliciting RPT-participants' SSMR. Although the evolution from modelling to coaching tutor support should not be equated with an evolution from tutor-prompted co-regulation to SSMR, the evolving dynamics between tutors and tutees did appear to create a platform for tutees to start engaging in social forms of metacognitive regulation, either co-regulating or sharing regulative acts (Rogat & Adams-Wiggins, 2014; Volet et al., 2009a). It should be noted, however, that RPT-groups' involvement in SSMR was not as extensive as their engagement in co-regulation or individually-oriented metacognitive regulation. RPT-participants moreover needed time and regulative practice to develop or optimise the skills required for sharing and reciprocally contributing to regulating the RPT-group's learning, given that their adoption of SSMR only significantly increased during the second half of the RPT-intervention.

Chapter 5 furthermore revealed that orientation and monitoring were significantly positively correlated with adopting a socially shared regulation focus, whereas planning and evaluation did not show a significant association. Additionally, a deep-level regulation approach encouraged RPT-groups more easily into SSMR, as compared to low-level regulation. These findings highlighted the importance of particular cognitive activities, more specifically profound processing and co-construction of knowledge, for eliciting RPT-participants' socially shared regulation focus. These frequently applied cognitive activities probably evoked RPT-participants' critical reflections on their own and each other's comprehension (during monitoring) or prior knowledge (during orientation), demanding for mutual negotiation of their conflicting understanding (Hurme et al., 2006; Khosa & Volet, 2014). It could be assumed that such reciprocal, reflection-provoking peer discussions facilitated students' shared metacognitive engagement at the interpersonal level (Iiskala et al., 2011; Volet et al., 2009a).

In sum, based on the findings described in chapter 4 and 5, three major conclusions can be put forward regarding the metacognitive potential of RPT, the importance of socio-cognitive conflicts, and the context-specificity of metacognitive regulation. First, we can conclude that collaborative learning during RPT spontaneously evoked and fostered RPT-participants' adoption of particular metacognitive regulation behaviour. The RPT-setting appeared especially fruitful for promoting orientation, evaluation, deep-level monitoring, tutee-prompted co-regulation, and SSMR. It should be noted, however, that different evolution patterns were revealed for tutors' and tutees' adoption of and initiative for particular regulation skills, their adoption of a deep-level regulation approach, and diverse regulative foci. The studies in the second research line consequently revealed the need for differentiated support when fostering RPT-groups' metacognitive regulation. Additionally they demonstrated that despite RPT's natural metacognitive potential, students needed time to engage in certain regulation behaviour (e.g. SSMR or tutee-initiated regulation), highlighting the added value of middle-long to long-term instructional interventions when fostering collaborative learners' (socially shared) metacognitive regulation (Molenaar & Järvelä, 2014; Perry & Winne, 2013).

Second, although it seems plausible that frequently applying particular regulation skills can enhance the probability of RPT-participants' engagement in complex regulation behaviour (i.e. deep level and socially shared regulation) (Greene & Azevedo, 2007; Molenaar & Järvelä, 2014; Rogat & Linnenbrink-Garcia, 2011), the second research line suggested that the particularities of students' metacognitive acts are more influential compared to their frequency of occurrence. More specifically, the occurrence of socio-cognitive conflicts – often elicited during prior knowledge activation and deep-level comprehension monitoring, when differences in students' reasoning are exposed – appeared to be important for evoking students' involvement in deep-level and socially shared metacognitive regulation.

Third, although both the first and the second research line confirmed the metacognitive benefits of RPT, it should be noted that its impact on students' metacognitive regulation differed according to the specific setting in which metacognitive regulation was adopted. During individual think-aloud problem solving, major increases were shown for task analysis, monitoring of both comprehension and progress, and evaluation of learning outcomes. On the other hand, collaborative learning during RPT mainly evoked students' prior knowledge activation, comprehension monitoring, and evaluation of both learning outcomes and the learning process. This finding confirms the context-specific dimension of metacognitive regulation: although learners develop a personal repertoire of metacognitive regulation skills and strategies, the instructional setting in which they operate determines to an important extent which particular regulation skills, approaches, or foci are applied by learners (Efklides, 2008; Veenman, van Hout-Wolters, & Afflerbach, 2006).

Research line 3: Studying the impact of metacognitive scaffolds on RPT-groups' adoption of metacognitive regulation

Although the first and second research line highlighted the value of RPT when fostering students' metacognitive regulation, both research lines also demonstrated that RPT does not engage students into a balanced adoption of or initiative for key regulation skills, regulation approaches, and regulative foci. The third research line therefore intended to study whether the metacognitive potential of RPT revealed in RL1 and RL2, can be optimised by providing RPT-groups with metacognitive scaffolds. It more specifically examined the impact of structuring versus problematising scaffolds on RPT-groups' adoption of key regulation skills, deep-level regulation, tutee-initiated regulation, and social forms of metacognitive regulation. Two empirical studies, described in chapter 6 and 7, were related to this research line. In both studies, 58 first-year students in the Educational Sciences programme who already obtained a Professional Bachelor degree, participated in a semester-long RPT-intervention in small groups of six students. A quasi-experimental design involving two experimental conditions, a structuring (SS) versus problematising scaffold (PS) condition, was adopted in each study. The first (at the start), third (halfway), and sixth RPT-session (upon completion) of eight randomly selected RPT-groups (i.e. four from the SS-condition, four from the PS-condition) were videotaped. Assessment of RPT-groups' metacognitive regulation was based on the observation of tutors' and tutees' verbalised interactions.

The study described in chapter 6 investigated the impact of both scaffold types on RPT-groups' adoption of key regulation skills, deep-level regulation, and tutee-initiated regulation, by means of two-way mixed ANOVA's. Our results indicated that RPT-groups made significantly more use of metacognitive regulation as the RPT-intervention progressed. However, no significant differences were found between the SS-condition and the PS-condition in the frequency of occurrence of adopted orientation, planning, monitoring, and evaluation strategies. In contrast, the PS-condition showed significantly higher increases in the adoption of deep-level monitoring, compared to the SS-condition. Both scaffold conditions did, however, not differ significantly in taking a deep-level regulation approach when applying other regulation skills. These findings suggest that problematising scaffolds' reflection-provoking nature particularly encouraged students to elaboratively discuss and restructure their reasoning, facilitating deep-level monitoring of their understanding (Molenaar et al., 2014; Volet et al., 2009a). In other words, problematising scaffolds appeared to have reinforced RPT's natural strength to engage students into profoundly monitoring their own and each other's understanding (King et al., 1998; Roscoe, 2014), but showed to be less conducive for evoking regulative behaviour which is less spontaneously demonstrated by RPT-participants.

Chapter 6 further revealed that problematising scaffolds encouraged tutees significantly more in initiating deep-level orientation and low-level monitoring, compared to structuring scaffolds. No beneficial influence of either scaffold type was shown for tutee-initiated planning or evaluation. Although these results suggest that problematising scaffolds facilitated the natural evolution from modelling to coaching tutor support as tutees became more experienced in RPT (De Smet et al., 2009; Rasku-Puttonen et al., 2003), they equally raise questions concerning the possible influence of RPT-participants' perceptions on tutors' versus tutees' responsibilities towards particular regulation behaviour (Robinson, Schofield, & Steers-Wentzell, 2005; Roscoe, 2014; Webb, Ing, Kersting, & Nemer, 2006). Since planning and evaluation could only be adopted at the start and upon completion of problem solving respectively (Greene & Azevedo, 2009; Meijer, Veenman, & van Hout-Wolters, 2006), tutees' chances for practicing with both regulation skills were limited (in both scaffold conditions). This might have promoted RPT-participants' perception of planning and evaluation being tutor-centred responsibilities (Robinson et al., 2005; Webb, 2009). On the other hand, orientation and monitoring might have been perceived more easily as shared responsibilities among tutors and tutees, given tutees' experienced need to express and regulate their prior knowledge and comprehension during conceptual peer discussions (Goos et al., 2002; Iiskala et al., 2011; Rogat & Linnenbrink-Garcia, 2011). This might have facilitated tutees' initiative for both regulation skills when these were problematised.

It should further be noted that structuring scaffolds negatively influenced tutees' initiative for regulating RPT-groups' learning, raising critical questions regarding their added value in a RPT-setting. Directly instructing students to regulate as demonstrated in the structuring scaffolds appeared to have stimulated tutors' metacognitive modelling, leaving limited space for tutees to shape the group's regulation (De Smet et al., 2009; Hadwin, Miller, & Järvelä, 2011; Rogat & Adams-Wiggins, 2014). Chapter 4 demonstrated, nevertheless, that non-scaffolded tutees spontaneously showed enhanced initiative for metacognitive regulation as they became more familiar with the RPT-setting. Therefore, it appears that structuring scaffolds' direct regulative guidelines might have "over"structured tutees' collaborative learning process (Dillenbourg, 2002; King, 2002; Stegmann, Weinberger, Fischer, 2007). Consequently, structuring scaffolds probably hindered the natural dynamics between tutor and tutees, directed at facilitating tutees' progressive contributions to the RPT-group's learning and regulation.

The study reported in chapter 7 investigated whether structuring and problematising scaffolds generated a differential impact on RPT-groups' adoption of tutor-prompted co-regulation, tutee-prompted co-regulation, and SSMR by conducting Mann-Whitney U tests. Additionally, it examined whether both scaffold types evoked other evolutions in RPT-groups' adopted social forms of metacognitive regulation by means of binary logistic regression analyses.

Chapter 7 revealed that structuring scaffolds elicited significantly more tutor-prompted co-regulation, compared to problematising scaffolds, whereas the latter evoked significantly more tutee-prompted co-regulation. Although it seems plausible that structuring scaffolds' directive nature might have appealed to tutors' pedagogical responsibility towards the RPT-group, encouraging them to orchestrate the group's learning (Hadwin et al., 2005; Rasku-Puttonen et al., 2003; Rogat & Adams-Wiggins, 2014), it should be noted that they simultaneously generated increased tutee-prompted co-regulation as well (albeit to a lesser extent compared to problematising scaffolds). This result highlights the natural strength of peers' interactions and learning experiences inherent to RPT, when fostering tutees' regulative engagement (Chi, Roy, & Hausmann, 2008; King et al., 1998; Roscoe, 2014).

The results described in chapter 7 further indicated that RPT-groups provided with problematising scaffolds not only evolved towards significantly enhanced adoption of SSMR but also demonstrated significantly more SSMR compared to RPT-groups that were given structuring scaffolds. In other words, challenging students to critically address their regulation appeared to have stimulated their regulative discussions and reflections, encouraging them to share regulative acts at the interpersonal level (Iiskala et al., 2011; Molenaar et al., 2014; Volet et al., 2009b). It should nevertheless be noted that significant differences in SSMR between the SS-condition and the PS-condition were only revealed upon completion of the RPT-intervention. This finding implies that collaborative learners needed time and practice to develop or optimise the skills required for sharing and reciprocally contributing to regulating the group's learning (Perry & Winne, 2013; Volet et al., 2009b). Metacognitive scaffolds (either structuring or problematising) can consequently not advance RPT-groups' SSMR as long as students' competence to engage in SSMR is insufficient (Veenman et al., 2006).

In sum, based on the findings described in chapter 6 and 7, we can conclude that problematising scaffolds are most beneficial for eliciting deep-level regulation, tutee-initiated regulative acts, tutee-prompted co-regulation, as well as SSMR. Problematising scaffolds' reflection-provoking nature more specifically appeared to have stimulated socio-cognitive conflicts during orientation and monitoring. Resolving these socio-cognitive conflicts probably demanded for elaborative discussion and cognitive restructuring (Iiskala et al., 2011; Khosa & Volet, 2014; King, 1998), facilitating both the adoption of deep-level regulation and tutees' regulative contributions during co-regulation and SSMR. This finding is important, especially given the dominance of structuring scaffolds in both educational research and practice (Molenaar et al., 2014; Reiser, 2004). Nevertheless, neither scaffold type generated a balanced adoption of metacognitive regulation skills, approaches, or foci. In contrast, problematising scaffolds merely reinforced RPT's natural potential to foster particular metacognitive regulation behaviour, whereas structuring scaffolds even appeared to be counterproductive for tutees' regulative engagement. As to these results, it should be noted, however, that RPT-groups were provided with static scaffolds, not adjusted to students' needs, which might explain why they appeared not to be powerful enough to elicit regulation behaviour which is less spontaneously applied by RPT-participants (Azevedo & Hadwin, 2005; Manlove et al., 2007). Adequately eliciting complex regulation processes which naturally require time and extensive practice (e.g. SSMR, tutee-initiated deep-level regulation) probably demanded for intensive and calibrated support, dynamically adapted to students' progressive understanding of regulating collaborative learning (Azevedo & Hadwin, 2005; Pea, 2004; Puntambekar & Hübscher, 2005).

Research line 4: Studying the correlates of RPT-groups' metacognitive regulation

Despite acknowledging the metacognitive benefits of peer tutoring, little process-oriented studies, aimed at clarifying which specific characteristics of collaborative learners' interactions evoke metacognitive regulation, have been conducted (Chi et al., 2008; Roscoe, 2014). Especially correlational research on SSMR is limited (Khosa & Volet, 2014; Molenaar & Järvelä, 2014). The fourth research line was consequently directed at identifying the correlates of RPT-groups' adoption of key regulation skills, deep-level regulation, and socially shared regulation focus. More specifically, the relationship of RPT-groups' regulation behaviour with their adopted content processing strategies on the one hand, the level of transactivity in their discussions on the other hand, was examined. Two empirical studies, described in chapter 8 and 9, were related to this research line. In both studies, 64 first-year students in the Educational Sciences programme who already obtained a Professional Bachelor degree, participated in a semester-long RPT-intervention in small groups of six students. All RPT-sessions of five randomly selected RPT-groups (30 students) were videotaped. Assessment of RPT-groups' metacognitive regulation was based on the observation of tutors' and tutees' verbalised interactions. Binary logistic regression analyses were conducted to investigate the abovementioned relationships.

The fourth research line revealed a significant positive association of RPT-groups' content processing and metacognitive regulation. Whereas questioning appeared especially important for RPT-groups' adoption of monitoring, explaining was shown to be conducive for orientation and evaluation. Planning was not significantly correlated with RPT-groups' content processing. Further, higher-order content processing appeared to be particularly important for eliciting both deep-level regulation (i.e. monitoring and orientation) and SSMR. Since higher-order content processing facilitates the control and revision of mental models (King, 1998; Rogat & Linnenbrink-Garcia, 2011), it seems plausible that RPT-participants' elaborative inquiries of each other's prior knowledge and comprehension were perceived as direct metacognitive prompts, stimulating deep-level regulation. Students' thought-provoking questions and knowledge-building explanations probably also engaged students more easily into mutual discussions on their reasoning and regulation of the group's learning (Hurme et al., 2006; Schraw et al., 2006), which might have fostered shared regulative acts at the interpersonal level (Khosa & Volet, 2014; Rogat & Linnenbrink-Garcia, 2011; Volet et al., 2009a). In contrast, when RPT-participants shared their thinking through lower-order knowledge-reviewing, they probably assessed their reasoning less and rather covertly (Chi et al., 2001; King et al., 1998; Webb et al., 2006), only limitedly challenging each other's mental models. This might explain why lower-order content processing was negatively correlated with RPT-groups' adoption of deep-level regulation and only limitedly associated with SSMR.

The results described in chapter 8 and 9 further revealed that non-transactive discussions, in which peers ignore each other's contributions, did not evoke (socially shared) regulative acts. In contrast, both cognitively-oriented and metacognitively-oriented transactive discussions were significantly positively correlated with RPT-groups' orientation, monitoring, and socially shared regulation focus. Whereas promoting RPT-participants' adoption of metacognitive regulation did not necessarily require students to transactively discuss regulative acts, their adoption of SSMR appeared to be strongly associated with such metacognitively-oriented transactive discussions.

Further, the degree to which students elaborated upon each other's contributions appeared to be less important for RPT-groups' adoption of deep-level regulation, given that representational transactive discussions (in which students' reactions merely represented initially expressed reasoning) and operational transactive discussions (in which students elaboratively operated on each other's reasoning) were both comparably correlated with a deep-level regulation approach. On the other hand, operational transactive discussions showed a much stronger association with SSMR, compared to representational transactive discussions, particularly when RPT-participants directly discussed their regulative acts. It appears that operational metacognitively-oriented transactive discussions more easily caused metacognitive conflicts, stimulating reflection and revision of adopted regulation strategies (Berkowitz, Althof, Turner, & Bloch, 2008; Webb, 2009; Weinberger, Stegmann, & Fischer, 2007) and giving input to discuss and collectively regulate the group's learning. On the other hand, merely repeating each other's regulative acts in representational metacognitively-oriented transactive discussions probably invited students less into reciprocal metacognitive contributions (Goos et al., 2002; Teasley, 1997).

In sum, the results described in chapter 8 and 9 indicate that the underlying dynamics of peer tutors' and tutees' interactions influenced their metacognitive regulation to an important extent. The fourth research line consequently provided valuable insights, enhancing our theoretical understanding why RPT is fruitful for eliciting particular regulation behaviour, clarifying the results on the impact of RPT revealed in the other research lines, and offering practical guidelines on how to promote collaborative learners' (shared) regulative engagement. Our findings further suggested that thought-provoking questioning and knowledge-building explaining, as well as transactively discussing learning content or regulative acts particularly occurred when RPT-participants shared, compared, and challenged their own and each other's reasoning in order to co-construct knowledge. This could explain why RPT appeared especially beneficial for eliciting collaborative learners' prior knowledge activation and comprehension monitoring, as was demonstrated in chapter 4. It could additionally clarify why RPT-participants particularly adopted a socially shared regulation focus during orientation and monitoring, as was revealed in chapter 5. It should be noted, nevertheless, that RPT-participants' content processing strategies and transactive discussions were differently correlated with specific regulation skills and RPT-participants' SSMR. This result confirms the added value of taking an integrative perspective on metacognitive regulation and highlights the need for differentiated support when promoting collaborative learners' (shared) regulation behaviour.

Limitations of the present dissertation

Although the present dissertation provides innovative insights advancing our theoretical understanding of collaborative learners' metacognitive regulation behaviour and allowing educators to optimally foster RPT-participants' adoption of particular regulation skills, approaches, and foci, its limitations should also be acknowledged. Chapters 2 to 9 described and discussed the limitations of each empirical study conducted. In the following paragraphs, a more general overview of the present dissertation's overall limitations is provided. More specifically, limitations regarding the research setting, study variables, and applied methodologies are discussed in more depth. Although some of the dissertation's limitations can directly be related to suggestions for future studies, a separate paragraph outlining major challenges for future research is presented thereafter (see p. 312).

Limitations regarding the research setting

The present dissertation comprises studies which were conducted in a particular instructional setting. Higher education students in the Educational Sciences programme of Ghent University participated in a semester-long same-age RPT-intervention, aimed at deepening their understanding of the learning contents of the course "Instructional Sciences", by working on open-ended group assignments directed at familiarising with course-specific terminology and theoretical notions. Although studying students' learning and metacognitive regulation behaviour in this authentic setting provided us with rich and authentic data, the particularities of the research setting make it rather difficult to generalise the obtained results. It is possible that diverse characteristics of the research setting (e.g. the study sample, peer tutoring format, structure and content of the academic tasks) generated a specific influence on students' adoption of metacognitive regulation, possibly optimising the impact of RPT. Future, preferably longitudinal, research with different student populations, other collaborative learning formats, different types of academic assignments, and other study domains, is therefore needed to verify whether and to what extent the current findings are representative for the metacognitive regulation behaviour of collaborative learners in higher education.

First, the possible influence of both the higher education context in which the studies were conducted and of the course "Instructional Sciences" should be acknowledged. Becoming acquainted with higher education's demands for self-regulation and self-management of one's learning during the first semester at university might have stimulated students' regulative development (Bruinsma, 2004; Nota et al., 2004). This might have advanced their metacognitive regulation behaviour during both the RPT-sessions and individual think-aloud problem solving. Empirical research further demonstrated that students' metacognitive regulation is correlated with their cognition and learning performance (Coutinho, Wiemer-Hastings, Skowronski, & Britt, 2005; Prins et al., 2006; van der Stel & Veenman, 2010). Students with higher levels of general and domain-specific knowledge are expected to show more extensive regulative engagement, often resulting in better performance (Greene & Azevedo, 2007; Zimmerman & Schunk, 2011). High levels of knowledge and academic experience are moreover assumed to positively influence the quality of learners' metacognitive regulation (Chin & Brown, 2000). In other words, RPT-participants' cognitive gains related to their regular curriculum activities might have facilitated their adoption of (deep-level) regulation. This study was moreover set up in relation to the course "Instructional Sciences", that introduced students to theories about learning and instruction as well as to the topic of metacognition. Students' enhanced domain-specific knowledge regarding the particular course content might therefore have been equally conducive for applying particular regulation skills, approaches, or foci, compared to the tutoring experience itself. Implementing a RPT-intervention in another course or study domain and organising RPT for younger students (e.g. primary or secondary school children) or participants with a different educational background (e.g. freshmen in natural sciences) might consequently yield a less beneficial influence on RPT-participants' metacognitive regulation.

Second, the present dissertation exclusively focussed on the metacognitive potential of same-age RPT organised in small groups. Nevertheless, it is possible that collaborative learning in other peer tutoring formats, non-tutoring settings, or in differently composed groups might generate a differential impact on students' adoption of and initiative for metacognitive regulation skills, approaches, and a socially shared regulation focus. Students' active participation might for example be higher and more intensive in dyads and triads, compared to small groups (Michinov & Michinov, 2009; Noroozi, Biemans, Weinberger, Mulder, & Chizari, 2013). Nevertheless, the small group composition in the present dissertation might have facilitated RPT-participants' transactive discussions as well as their mutual regulative acts more easily, given the larger communicative, cognitive, and metacognitive input of multiple peers inspiring each other to take into account peers' expressed thinking (Kirschner, Paas, & Kirschner, 2009; Rogat & Linnenbrink-Garcia, 2011; Teasley, 1997; Webb, 2009). This might in its turn have fostered RPT-participants' reasoning, adoption of (deep-level) metacognitive regulation, tutees' initiative for regulation, as well as RPT-participants' socially shared regulation focus. Further, the same-age and reciprocal nature of the peer tutoring intervention studied in the underlying dissertation, possibly influenced tutors' and tutees' perceptions on each other's role, corresponding responsibilities, and social status in the collaborative learning group (Colvin, 2007; Robinson et al., 2005; Roscoe, 2014). Students' perceptions were, however, not included in the research design. It seems, nevertheless, plausible that rotating the tutor role among same-ability collaborative learners might have prevented students to perceive and approach the tutor as a permanently directive group member who is expected to initiate and orchestrate tutees' learning and regulation throughout the complete RPT-intervention and who has therefore obtained a higher social status compared to the tutees (Colvin, 2007; Roscoe, 2014). In contrast, cross-age or cross-ability peer tutors in a fixed peer tutoring format might direct tutees' collaborative learning and regulation more explicitly, due to developmental differences in their metacognition (Duran & Monereo, 2005; Molenaar et al., 2014). Cross-age peer tutors might therefore be perceived as principal decision-makers who should be attributed higher social status (Colvin, 2007; Robinson et al., 2005). On the one hand, cross-age peer tutors' more explicit and prolonged modelling of metacognitive regulation might enhance tutees' metacognitive awareness (Schraw et al., 2006; Schunk & Zimmerman, 2007), facilitating their initiative for co-regulating peers' learning or socially sharing regulative acts (Rogat & Adams-Wiggins, 2014; Vauras & Volet, 2013). On the other hand, tutees' perceptions of the tutor exclusively being responsible for tutees' collaborative learning might as well hamper their regulative engagement, possibly influencing the group's transactive discussions and SSMR negatively (Robinson et al., 2005; Roscoe, 2014; Webb et al., 2006). Future research is needed to clarify the impact of cross-age peer tutors' role taking and perceived social status on tutees' contributions to the peer discussions and socially shared regulative acts. Similarly, the face-to-face context in which the current RPT-intervention was implemented might have fostered students' higher-order learning and advanced regulation behaviour through peers' immediate and mutual reactions in sequential conversational exchanges (Chi et al., 2001; King et al., 1998; Roscoe, 2014; Teasley, 1997). Given that collaborative learners operating in a computer-supported (peer tutoring) setting are frequently involved in short and non-reciprocal discussions, often aimed at reviewing instead of profoundly processing information (Molenaar et al., 2014; Pifarré & Cobos, 2010), it can be assumed that computer-supported collaborative learning might generate a differential impact on students' (socially shared) metacognitive regulation. In sum, since the present dissertation did not compare the metacognitive benefits of different peer tutoring or other collaborative learning formats, it remains questionable to what extent RPT can be considered as the most beneficial instructional setting when aiming at fostering higher education students' metacognitive regulation.

Third, although it can be assumed that the academic task performed by students partly determines the content, intensity, and outcomes of peers' interactions and learning activities (Barron, 2003; Perry & Winne, 2013; Pifarré & Cobos, 2010), the present dissertation did not take into account the possible task-specific impact on RPT-participants' metacognitive regulation. It did for example not examine whether different types of tasks generated a differential impact on students' metacognitive regulation behaviour. In contrast, in all empirical studies, students were provided with open-ended academic assignments aimed at deepening students' understanding of theoretical course contents (both during the RPT-sessions and during individual think-aloud problem solving). Nevertheless, the design and instructions of these assignments might have stimulated students to particularly monitor their own or each other's learning, but might have been less appropriate to evoke and assess (a socially shared regulation focus during) other regulative activities. Future research with alternative task formats would therefore be helpful to rule out the possibility that the academic assignments might be equally or more decisive for students' regulative engagement as compared to the RPT-context itself.

Fourth, it should be acknowledged that organising face-to-face RPT for a medium-size group of students and implementing it as a formal component of their curriculum, is complex and labour-intensive (Falchikov, 2001; Topping, 2005). Since RPT-sessions were simultaneously organised for multiple RPT-groups in separate classrooms and given that only one university staff member was available for providing ongoing support to all RPT-participants, it should not be surprising that little time was available for close follow-up of each RPT-group. The provided ongoing support was consequently rather limited, consisting of group-specific feedback sessions every two weeks and an interim supervision session halfway through the RPT-intervention. Additionally, static scaffolds were integrated in the RPT-learning materials for the studies described in chapter 6 and 7. It could be assumed, however, that successfully fostering complex regulation behaviour (e.g. applying SSMR or deep-level regulation) requires more intensive support that is adapted to the changing group-specific learning and regulation needs (Azevedo & Hadwin, 2005; Manlove et al., 2007; Puntambekar & Hübscher, 2005). Intensively assisting RPT-groups in adopting regulation behaviour which is less spontaneously demonstrated and providing them with calibrated support, based on ongoing diagnosis of their spontaneous versus potential regulative acts might consequently optimise the metacognitive benefits of RPT.

Last, it should be noted that the RPT-intervention was implemented for one semester and consisted of weekly sessions each taking two hours. Although the present dissertation revealed that even such middle-long term interventions have the potential to advance RPT-participants' adoption of particular regulation skills, approaches, and foci, it should be acknowledged that long-lasting and probably more intensive interventions (e.g. organising RPT-sessions more frequently or implementing comparable and simultaneous RPT-interventions in different courses of students' curriculum) are needed to examine whether RPT can generate an enduring impact and whether the latter can be transferred to other (collaborative) learning situations (Molenaar & Järvelä, 2014; Vauras & Volet, 2013). The middle-long duration of the current RPT-intervention might have especially been insufficient to benefit students' engagement in complex regulation behaviour, which naturally requires time and extensive practice in order to be applied appropriately (e.g. SSMR) (Hadwin et al., 2011; Perry & Winne, 2013).

Limitations regarding the variables included in the research design

Collaborative learning concerns a complex interplay of cognitive, metacognitive, communicative, and socio-emotional processes among multiple students (Barron, 2003; Dillenbourg, 1999; VanLehn, Siler, & Murray, 2003). Although both the outcomes and peers' ongoing interactions are partly determined by individual learners' and group-specific characteristics (Barron, 2003; Chi, 2009; King, 1998; Webb & Mastergeorge, 2003), these influential factors were not taken into account in the studies of the present dissertation. Additionally, the focus was exclusively put on students' or RPT-groups' metacognitive regulation behaviour, without investigating whether and how RPT-participants' adopted regulation skills, approaches, and foci influenced their learning process or outcomes. In other words, the variables included in the research design were not sufficient to comprehend RPT's metacognitive potential to the fullest.

Although all students who participated in the RPT-intervention in the consecutive studies concerned first-year students of the Educational Sciences programme who previously obtained a Professional Bachelor degree, they cannot be considered a homogeneous group. Apart from differences in ability and prior educational experiences, individual students might have differed in a variety of person-related characteristics (Barron, 2003; Dillenbourg, 1999; VanLehn et al., 2003). It could moreover be assumed that these individual learner characteristics determined to an important extent the way students operated in the RPT-groups and contributed to (regulating) the collaborative learning process (Chi, 2009; Teasley, 1997; Volet et al., 2009b). It seems for example plausible that students with low versus high levels of motivation for academic education, the specific course contents, or RPT as an instructional approach, might have participated to a lesser or larger extent in RPT, which in its turn might have affected their engagement in (socially shared) regulative acts (Järvenojä et al., 2013; Pintrich, 2002; Zimmerman & Moylan, 2009). Similarly, low- versus high-achievers or novices versus students with enlarged domain-specific expertise might have taken a different social position in the RPT-group, which possibly affected their initiative for and adoption of cognition and metacognition (Iiskala et al., 2011; Rogat & Adams-Wiggins, 2014; Volet et al., 2013). Additionally, students' preference for experiential or reflective learning (Kolb & Kolb, 2005; Vermetten, Lodewijks, & Vermunt, 1999), their self-efficacy beliefs (Pintrich, 2004; Zimmerman, 1990), their willingness to approach peers for academic help or attentiveness to reply to peers' help-seeking (Barron, 2003; Webb et al., 2006) probably influenced their learning and regulation during RPT. Further, students' perceptions of the tutor versus tutee role and corresponding responsibilities, as well as students' preference or appreciation for taking one of both roles, might have been influential (Falchikov, 2001; Robinson et al., 2005; Roscoe, 2014). It should further be noted that particularly tutors' role taking might have been decisive for RPT's metacognitive benefits, given peer tutors' pedagogical responsibility to foster collaborative learning among tutees (McLuckie & Topping, 2004; Roscoe & Chi, 2008). Differences in individual peer tutors' background and prior experience might consequently have contributed more to students' metacognitive regulation, compared to the RPT-setting itself. By analysing general trends in RPT-groups' metacognitive regulation behaviour, aggregating data of individual RPT-participants, the present dissertation did, however, not acknowledge the possible impact of individual learner characteristics on the learning and regulation processes taking place during RPT. In line with this, it could equally be assumed that RPT might have generated a differential impact for different types of students (e.g. low-, average-, or high-achievers; novices, students with limited domain-specific prior knowledge or tutoring experience, or experts; students demonstrating low, average, or high levels of metacognitive knowledge and self-regulation) (Iiskala et al., 2011; Järvelä et al., 2013; Rogat & Linnenbrink-Garcia, 2011; Volet et al., 2009b). The studies included in the dissertation did, nevertheless, not take into account various learner profiles for which RPT might have been less or more beneficial.

Since each student brings specific abilities, beliefs, knowledge structures, and experiences into the collaborative learning group, which might be less or more in line with those of collaborating peers, and given that collaborative learners start to apply routines once they become familiar with each other and the collaborative learning setting (Barron, 2003; Dillenbourg, 1999; Roscoe & Chi, 2007; Webb & Mastergeorge, 2003), it could be assumed that RPT-groups also differed in their learning and regulation, based on group-specific characteristics. It seems for example plausible that positive socio-emotional peer interactions, characterised by active listening, supportive help giving, and group cohesion, might have benefited RPT-participants' collaboration, facilitating their adoption of (socially shared) regulative acts (Chi, 2009; Järvenojä et al., 2013; Rogat & Linnenbrink-Garcia, 2011; Volet et al., 2009a). On the other hand, negative socio-emotional peer interactions (e.g. poor synergy among group members, unequal participation of diverse peers, lack of negotiation, or disrespecting each other's interpretations or proposals) might have generated a negative impact on RPT-participants' contributions to the collaborative learning and regulation processes. Correspondingly, although students were randomly assigned to RPT-groups, it can be assumed that RPT-participants' prior relationships (e.g. never having met before, knowing each other superficially, or being close friends) might have affected the way they interacted and shared learning and regulation activities (Barron, 2003; Webb et al., 2006). By examining the metacognitive potential of RPT in general, aggregating the obtained data of separate RPT-groups, the present dissertation did, however, not take into consideration the possible influence of group-related particularities.

It should further be noted that all empirical studies included in the present dissertation exclusively examined RPT-participants' metacognitive regulation behaviour. It is widely acknowledged that adequately regulating (collaborative) learning benefits students' learning outcomes as well (Molenaar et al., 2014; Pintrich et al., 2000; Veenman et al., 2006; Winne, 2011). However, based on the current findings, no claims can be made in this respect, given that output-related variables were not included in the conducted studies. Future research is therefore needed to investigate whether RPT-groups' metacognitive regulation behaviour resulted in successful problem solving and productive learning outcomes. Especially output-related research on SSMR as well as on problematising scaffolds could advance the literature on collaborative learners' metacognitive regulation, since research on the impact of both on collaborating peers' learning is limited (Khosa & Volet, 2014; Molenaar et al., 2014; Rogat & Adams-Wiggins, 2014; Vauras & Volet, 2013).

Methodological limitations

Although unravelling the interactional dynamics between collaborative learners in an authentic RPT-setting enhanced our understanding of RPT-participants' regulative engagement, the present dissertation's process-oriented research perspective and corresponding data gathering techniques and assessment instruments also demonstrated some methodological constraints.

Although chapter 2 indicated that off-line measures of students' metacognitive regulation by means of self-report instruments could easily be administered to large study samples, the adopted self-report questionnaire was probably not sensitive enough to accurately measure changes in students' metacognitive knowledge and regulation after participation in RPT (Azevedo, 2009; Bannert & Mengelkamp, 2008; Veenman, 2005). Given the critical questions raised regarding the accuracy of self-reported off-line assessment of metacognitive regulation, the present dissertation dominantly applied on-line assessment techniques to identify individual students' and RPT-groups' metacognitive regulation behaviour, by means of think-aloud protocol analysis and observation of regulation in videotaped RPT-sessions. While the think-aloud methodology is generally accepted as a useful source of data providing insight in the covert (meta)cognitive structures and processes underlying learning or academic problem solving (Ericsson & Simon, 1993; Pintrich et al., 2000; van Someren et al., 1993; Veenman, 2005), its limitations should equally be acknowledged. Despite being prompted to verbalise, it seems plausible that students not always explicitly articulated their thinking and regulation, for example when applying automated processes (Bannert & Mengelkamp, 2008; Vauras & Volet, 2013). Consequently, the identification of metacognitive utterances in the verbal protocols obtained in chapter 2 and 3, might not have been completely exhaustive. Additionally, asking students to verbalise their thinking might have increased their awareness of cognitive and regulative activities, which in its turn might have encouraged them to verbalise more and other metacognitive regulation behaviour then they would have demonstrated spontaneously (Ericsson & Simon, 1993; Greene et al., 2011; Veenman, 2005). In comparison, observation of students' metacognitive regulation is assumed to interfere less with students' learning (Azevedo, 2009; Veenman, 2011). The present dissertation revealed nevertheless that identifying students' covert metacognitive regulation processes through observation remains methodologically challenging.

Analysing tutorial dialogue data provided rich and informative results given the depth of coding. However, the time- and labour-intensive character of collecting, coding, and analysing research data obtained through on-line assessment puts constraints on the sample size (Järvenojä, Volet, & Järvelä 2013; Perry & Winne, 2013; Volet, Vauras, Khosa, & Iiskala, 2013). Although a medium-size group of students participated in the implemented RPT-interventions, data was collected from a rather small number of students in all conducted studies. The results of the empirical studies should consequently be interpreted with caution, since the small sample sizes compromise the degree to which findings can be generalised since they do not reflect representative variability in the study sample. Although future studies are encouraged to corroborate the present dissertation's findings in larger-scale research, finding a better compromise between sample size and representativeness of the results on the one hand and grain size of coding thick dialogue data on the other hand, remains difficult (Khosa & Volet, 2014; Molenaar & Järvelä, 2014; Volet et al., 2013).

The small sample sizes also constrained the applicable data analysis techniques. Although measurement occasions (i.e. assessment of RPT-participants' metacognitive regulation at particular RPT-sessions) were clustered within students and individual RPT-participants were clustered in small RPT-groups, the small sample size did not always allow taking into account the nested nature of data by conducting multilevel data analysis techniques. Regarding the data analysis, it should further be noted that some variables appeared not to be normally distributed (e.g. chapter 7), resulting in nonparametric testing of the formulated hypotheses. Nonparametric methods demonstrate, however, less statistical power compared to parametric hypothesis testing, especially when conducting analyses on small samples. Researchers should therefore aim at collecting data on a large sample of collaborative learners in future studies, allowing them to take the underlying distribution and hierarchical nesting of the data into account when analysing the impact of RPT on students' metacognitive regulation.

Furthermore, assessment of RPT-participants' individual and socially shared metacognitive regulation in the present dissertation was exclusively based on students' verbalised metacognitive actions, while it can be assumed that students did not always articulate their (regulative) reasoning. This implies that the measurement of students' and RPT-groups' adopted metacognitive regulation skills, approaches, and foci was probably not exhaustive for all metacognitive utterances during think-aloud problem solving or when tutoring each other. Moreover, given that SSMR is frequently demonstrated in non-verbal interactions (Iiskala et al., 2011; Volet et al., 2013), the identification of RPT-groups' regulative foci in chapters 5, 7, and 9 was probably not complete either. It should further be noted that by focussing on the occurrence of individual students' and RPT-groups' metacognitive regulation skills, approaches, and foci, the empirical studies did not grasp the dynamics of RPT through which (social forms of) metacognitive regulation, more especially SSMR, emerged (Molenaar & Järvelä, 2014). Visualising RPT-groups' regulation processes in future studies might clarify how SSMR is elicited and fine-tuned through students' social interactions.

It should further be noted that quantifying tutorial dialogue data and subsequently transforming the quantified codes on RPT-groups' metacognitive regulation into binary data, for example to examine the relationship with students' content processing and transactive discussions in chapters 8 and 9, implied a reduction of inherently informative data. Optimally acknowledging the richness of the collected video data probably demanded for a more qualitative research perspective, for example by means of case studies (Järvelä, Järvenojä, Malmberg, & Hadwin, 2013; Rogat & Linnenbrink-Garcia, 2011; Vauras & Volet, 2013). Detailed examination of for example low-versus high-achieving RPT-participants or RPT-groups which poorly versus strongly share regulative acts, which are followed-up closely throughout the entire RPT-intervention might have provided informative and innovative insights regarding the differentiated effectiveness of RPT for different types of students' or collaborative learning groups' metacognitive regulation behaviour. Rigorously studying the learning and regulation behaviour of different cases, as well as investigating how personal characteristics of RPT-participants or RPT-groups influence the way students operate and regulate in the RPT-groups, combining different qualitative research techniques (e.g. observations, interviews, analysis of learning diaries, etc.), would have acknowledged the strength of the obtained video data more, compared to the conducted correlational analyses on data derived from a relatively small sample of RPT-participants.

Last, a critical remark should be raised regarding the coding instrument (i.e. RPT_MCR) which was developed and adopted to code RPT-groups' metacognitive regulation during the videotaped RPT-sessions. Since standardised measures assessing collaborative learners' (socially shared) metacognitive regulation are not available to date (Khosa & Volet, 2014; Molenaar & Järvelä, 2014; Vauras & Volet, 2013), a literature-based coding instrument was developed as part of the present dissertation. This instrument succeeded in identifying and capturing RPT-participants' adopted metacognitive regulation skills, approaches, and foci, and consequently allowed to answer the research questions posed. Nevertheless, it is to be verified to what extent the developed coding instrument is also useful to assess collaborative learners' metacognitive regulation behaviour in other (non-tutoring) settings, given its study-specific character (Grau & Whitebread, 2012; Khosa & Volet, 2014; Pintrich et al., 2000).

Directions for future research

Based on both the limitations of the present dissertation and trends in recent literature on metacognitive regulation in collaborative learning settings, we can put forward an agenda for future research. In this respect, concrete suggestions for future studies are outlined below.

Although the present dissertation highlighted the value of RPT when fostering higher education students' (socially shared) metacognitive regulation, the generalizability of the obtained results to other collaborative learning settings, younger students (e.g. of primary or secondary education), and more diverse learner populations (e.g. students from other educational backgrounds) remains questionable. To increase the ecological validity of the present dissertation's findings, an increasing number of future studies on the (socially shared) metacognitive regulation behaviour of RPT-groups composed of university students with diverse backgrounds (e.g. freshmen, Master students with more extensive experience in higher education), recruited from other study domains (e.g. engineering, medicine, mathematics), or working on different types of group assignments (e.g. problem solving scripts which guide RPT-participants more explicitly towards problem solving steps and corresponding regulative acts, assignments comprised of closed questions which require a single right answer, or one overarching RPT-assignment which should be conducted during multiple subsequent RPT-sessions), is needed. It is additionally advisable to conduct comparable future studies in primary and secondary education, as well as studies with RPT-dyads or triads, other peer tutoring formats (e.g. cross-age, fixed, or computer-supported peer tutoring) or non-tutoring control groups (e.g. problem-based learning), in order to examine whether obtained results are inherent to the current research setting or are applicable to other collaborative learning experiences as well. Comparative research would furthermore allow to identify which collaborative learning setting is most beneficial for promoting (higher education) students' individual and socially shared regulation behaviour.

The present dissertation confirmed the strength of taking a process-oriented research perspective and assessing students' metacognitive regulation concurrently to learning, by means of think-aloud protocol analysis (chapters 2-3) and observation (chapters 4-9). Although this provided us with rich and informative data on students' actual engagement in particular regulation skills, approaches, and foci, the limitations of on-line assessment were also demonstrated (e.g. non-verbalised regulative acts remained unidentified). Additional coding of RPT-participants' non-verbal communication in future studies (Iiskala et al., 2011; Volet et al., 2013), as well as data-triangulation by means of stimulated recall interviews with tutors and tutees, allowing them to express and clarify their regulative thinking and actions (Anderson, Nashon, & Thomas, 2009; Artzt & Armour-Thomas, 2001; Iiskala, Vauras, & Lehtinen, 2004), might therefore be helpful. In line with the current call for on-line multi-method assessment of metacognitive regulation (Azevedo, 2009; Molenaar & Järvelä, 2014; Perry & Winne, 2013; Vauras & Volet, 2013), collecting software logged trace data during computer-supported RPT (Bannert & Reimann, 2012; Greene & Azevedo, 2009; Hurme et al., 2006; Perry & Winne, 2013) or applying eye-tracking methodology (Azevedo et al., 2010; van Gog & Jarodzka, 2013) would also be valuable to capture RPT-participants' metacognitive regulation behaviour in a more comprehensive way. Since collaborative learners' social position in the group (e.g. taking a central versus marginal place in the group) determines their opportunities to participate in learning and (joint) regulative acts (Barron, 2003; Rogat & Adams-Wiggins, 2014; Webb et al., 2006), it could additionally be interesting to visualise the collaborative learning and regulation processes which emerge during RPT in future research. Visualising RPT-participants' social interactions, for example by means of social network analysis (Hurme et al., 2006; Järvenojä et al., 2013), could grasp the dynamics through which social forms of metacognitive regulation, as well as transactive discussions are elicited, shaped, and supported when peers tutor each other. Additionally, social network analysis could provide measures of learning and regulation at both the individual and the group level. These would be valuable to examine the effects of RPT-groups' involvement in particular regulation skills, approaches, and socially shared regulation focus on the group's collaboration and learning, as well as on individual participants' learning outcomes in future studies (Perry & Winne, 2013; Volet et al., 2013).

In order to fully comprehend the metacognitive benefits of participating in RPT, it would further be interesting to include individual learner characteristics (e.g. academic achievement, motivation, self-efficacy beliefs, self-regulative competence, learning style, social status) and group-related factors (e.g. group cohesion, open/closed communication, help-seeking and help-giving behaviour, division of tasks, group composition) as mediating variables in future research designs (Iiskala et al., 2011; Järvelä et al., 2013; Pintrich, 2002; Rogat & Linnenbrink-Garcia, 2011; Teasley, 1997; Volet et al., 2009b; Webb et al., 2006). This would allow filtering out the specific impact of the RPT-experience on students' metacognitive regulation behaviour. Additionally, it would provide clarifying insights regarding the conditions which should be fulfilled for RPT to become a fruitful environment for promoting students' metacognitive regulation. In line with this, long-term developmental data is needed to fully comprehend and optimally promote collaborative learners' (socially shared) metacognitive regulation (Molenaar & Järvelä, 2014; Perry & Winne, 2013). Longitudinal research is also required to study whether RPT can generate an enduring impact (van der Stel & Veenman, 2010). It would furthermore allow investigating whether RPT can enhance students' metacognitive awareness and purposeful involvement in particular regulation behaviour (Hadwin et al., 2011; Manlove et al., 2007; Schraw, 1998). Both are important for transferring and optimising regulation behaviour elicited during the RPT-sessions to other learning situations or future collaborative learning groups (Efklides, 2008; Veenman et al., 2006; Volet et al., 2009b).

Further, taking a more qualitative research perspective in future studies would not only acknowledge the richness of observational data on collaborative learners' metacognitive regulation, but could also unfold the complex interplay between social, cognitive, communicative, and regulative processes among collaborating peers (Järvelä et al., 2013; Järvenojä et al., 2013; Rogat & Adams-Wiggins, 2014; Vauras & Volet, 2013). The findings of the present dissertation appeared to suggest, for example, that RPT-groups' adoption of social forms of metacognitive regulation (i.e. tutee-prompted co-regulation and SSMR) are up to some extent connected to peer tutors' naturally evolving support from modelling to coaching, as well as to RPT-participants' perceptions of the tutor versus tutee role. Nevertheless, in-depth analysis of a limited number of cases, analysing students' perceptions and intentions and relating these to their adoption of and initiative for particular learning and regulation activities, is needed to fully understand the identified evolutions in RPT-participants' regulative engagement. Additionally, rigorously portraying the learning and regulation behaviour of for example low-versus high-achieving RPT-participants; novices versus experts; RPT-groups which poorly versus strongly share regulation; or RPT-participants demonstrating low, moderate, or high levels of self-regulation or metacognitive awareness, would furthermore allow to study whether RPT is less or more beneficial for specific groups of students (Järvelä et al., 2013; Rogat & Linnenbrink-Garcia, 2011; Volet et al., 2013).

Given that the research on SSMR is still in its infancy (Molenaar & Järvelä, 2014; Vauras & Volet, 2013), possible directions for future studies in this respect are many. Based on the findings and limitations of the studies on SSMR included in the present dissertation (chapter 5, 7, and 9), we set out the following agenda for future research on SSMR. First, although it is widely assumed that adopting a socially shared regulation focus advances collaborative learners' problem solving and results in productive learning outcomes, there is only limited empirical evidence confirming this hypothesis (e.g. Järvelä et al., 2013; Khosa & Volet, 2014). Future research is needed to investigate whether and how adopting SSMR benefits both individual students' and the collaborative learning group's learning, implying that learning measures (e.g. measures of domain-specific learning gains, academic achievement, cognitive reasoning, etc.) should be included as output-related variables in future research designs (Molenaar & Järvelä, 2014; Rogat & Adams-Wiggins, 2014). Since the impact of collaborative learning on group-related versus individual group members' outcomes is sometimes conflicting (Kirschner et al., 2009; Michinov & Michinov, 2009), it will further be interesting to examine whether the effects of SSMR on RPT-groups' learning outcomes are also transferable to individual RPT-participants. This is in line with the current call for assessing learning and regulation simultaneously at the individual student level and at the group level and for examining the dynamic interplay between both levels (Grau & Whitebread, 2012; Khosa & Volet, 2014; Perry & Winne, 2013). It will in this respect also be important to go beyond the present dissertation's conceptualisation of SSMR as a specific social form of metacognitive regulation and to examine whether SSMR can also be interpreted as a transitional phase towards (optimised) self-regulation (DiDonato, 2013).

By investigating whether RPT-groups' adoption of particular regulation skills and approaches, content processing strategies, and transactive discussions facilitate or rather hamper RPT-groups' socially shared regulation focus, the present dissertation extended prior studies' focus on refining the conceptualisation of SSMR (Grau & Whitebread, 2012; Iiskala et al., 2011; Volet et al., 2009a). Nevertheless, optimally eliciting and promoting collaborative learners' SSMR requires more and deeper insight into the relation between SSMR and other aspects of the collaborative learning setting or individual students' characteristics (Iiskala et al., 2011; Järvelä et al., 2013; Molenaar & Järvelä, 2014; Perry & Winne, 2013; Rogat & Linnenbrink-Garcia, 2011). Future research should therefore be directed at studying alternative correlates of collaborative learners' adoption of SSMR (e.g. cognitive, socio-emotional, communicative, or task-specific features typifying students' interactions and collaboration during RPT). Additionally, it would be interesting to investigate how collaborative learners' joint engagement in regulative acts can best be supported. Since the present dissertation revealed that static scaffolds are only limitedly beneficial for encouraging students' involvement in complex regulation behaviour (e.g. SSMR), future research should aim at examining the impact of dynamic scaffolding, adjusted to collaborative learners' progressive expertise in socially regulating collaborative problem solving, or a human agent offering external regulation by intensively assisting collaborative learners in performing SSMR (Azevedo & Hadwin, 2005; Manlove et al., 2007). In addition to investigating the impact of such intensive and calibrated support on collaborative learners' SSMR, future studies should also investigate its relationship with successful problem solving and students' productive learning outcomes (DiDonato, 2013; Molenaar et al., 2014).

Further and in line with the current call to take into account quality differences in students' metacognitive regulation behaviour, another challenge to be tackled in future research concerns the conceptualisation and empirical identification of low- versus high-quality socially shared regulative acts (in line with the low- versus deep-level approach to regulation, introduced in the present dissertation). Utterances of low- versus high-quality SSMR could for example be conceptualised based on the low versus high level of regulative synergy among all collaborative learners; the undermining versus facilitating impact of SSMR on the collaborative learning process; the negative versus positive socio-emotional relations among collaborative learners; and the degree to which students merely repeat or elaborate upon each other's regulative acts (Iiskala et al., 2011; Rogat & Adams-Wiggins, 2014; Volet et al., 2009a). In addition to identifying quality differences in collaborative learners' SSMR, future studies should also aim at investigating whether differences in the quality of SSMR are connected with differences in collaborative learners' performance or understanding of the subject matter (Järvelä et al., 2013; Rogat & Linnenbrink-Garcia, 2011).

Implications of the dissertation

Although the metacognitive benefits of collaboratively learning with peers are widely acknowledged, in-depth studies of collaborative learners' metacognitive regulation behaviour are limited (Hadwin et al., 2011; Roscoe, 2014; Vauras & Volet, 2013). The findings of the present dissertation consequently contribute to the literature and related empirical research on metacognition and peer tutoring in important ways. The studies included in the dissertation not only advance our theoretical understanding of RPT-participants' regulative engagement, they also outline major challenges for future research in this respect. Additionally, they provide educational practitioners and institutions for higher education with valuable insights on how to optimise collaborative learners' metacognitive regulation behaviour. The following paragraphs describe both the theoretical and practical implications of the dissertation's findings in more detail.

Implications for theory and empirical research

By analysing collaborative learners' metacognitive regulation through direct observation of their diversified regulation behaviour in a process-oriented way, the present dissertation contributed innovative insights to the literature on metacognitive regulation in collaborative settings (Molenaar & Järvelä, 2014; Rogat & Adams-Wiggins, 2014; Volet et al., 2013). More specifically, its integrative operationalization of metacognitive regulation, in-depth analysis of time-bound evolutions in RPT-groups' regulation behaviour, and its attention for RPT-groups' socially shared regulative acts provided an innovative scope in the metacognition research. Unlike many other studies (e.g. King et al., 1998; Moos & Azevedo, 2009; Schraw, 2009), the present dissertation did not focus exclusively on one particular regulation skill (e.g. monitoring), but acknowledged students' differential engagement in diverse key regulation skills (i.e. orientation, planning, monitoring, and evaluation) and a variety of more concrete regulation strategies, proposing a more complete operationalization. By explicitly distinguishing low-level from deep-level regulation and conceptualising this difference in regulation approach for each key regulation skill, the present dissertation further introduced a more in-depth operationalization of metacognitive regulation. This might moreover encourage scholars studying metacognition more easily to direct their future research on both the frequency and the quality of regulation (Volet & Summers, 2013; Zimmerman & Schunk, 2011). By unfolding diverse processes during collaborative learning (i.e. questioning, explaining, and transactively discussing content matters and regulative acts) and relating these to students' differential involvement in specific regulation skills and approaches, the present dissertation further advanced our theoretical understanding of collaborative learners' adoption of particular regulation behaviour.

Although optimising collaborative learning groups' regulation requires initial insight in students' progressing adoption of metacognitive regulation, to our knowledge, detailed evolutions in collaborative learning groups' metacognitive regulation behaviour have not been portrayed before. The present dissertation's micro-analytical process-oriented perspective on time-bound evolutions in

RPT-groups' adoption of regulation skills, approaches, and foci therefore directly extended prior research on metacognition in collaborative settings, which is mainly causal and output-related (Grau & Whitebread, 2012; Molenaar & Järvelä, 2014; Perry & Winne, 2013). Further, the identification of critical change points in RPT-groups' adopted regulation behaviour not only implied a methodological innovation, but also provided valuable insights regarding the diversified development of collaborative learners' engagement in particular regulative acts. These innovative insights regarding how and when collaborative learners (increasingly) apply different regulation skills, approaches, and foci additionally provided input for future intervention studies aimed at optimally supporting collaborating peers' metacognitive regulation.

The present dissertation further advanced the emerging literature on social forms of metacognitive regulation, given its in-depth study of RPT-groups' socially shared regulative acts. By acknowledging the temporal dynamics of SSMR when portraying RPT-groups' evolving adoption of diverse regulative foci (chapter 5), the present dissertation refined the conceptualisation of SSMR as a series of events that unfold over time during particular learning and regulation activities (Molenaar & Järvelä, 2014; Perry & Winne, 2013). Further, it extended prior research's focus on validating the existence of social forms of metacognitive regulation, by identifying conditions which facilitate collaborative learners' adoption of SSMR. The studies included in the present dissertation more specifically demonstrated that RPT-participants' engagement in deep-level orientation and monitoring, higher-order content processing, and operational transactive discussions promoted their involvement in SSMR. Providing students with problematising scaffolds benefitted their shared regulative engagement as well. The latter finding is important and furthers the research on metacognitive scaffolds, given the dominance of structuring scaffold interventions in both educational studies and practice (Molenaar et al., 2014; Reiser, 2004). By unravelling correlates of RPT-participants' SSMR and highlighting the instructional value of problematising scaffolds, the present dissertation additionally allowed the research community to take the research on SSMR to a next level. It more specifically provided input for studies on the impact of instructional interventions aimed at optimising collaborative learners' SSMR.

The process-oriented studies on RPT-participants' metacognitive regulation included in the present dissertation not only advanced the research on metacognition but also contributed to the literature on peer tutoring. Previous studies mainly validated the beneficial impact of tutoring peers on students' monitoring (King et al., 1998; Roscoe, 2014; Shamir & Tzuriel, 2004). The present dissertation deepened our insight in the strength of peer tutoring by demonstrating that RPT is also fruitful for promoting students' adoption of orientation and evaluation, deep-level regulation, as well as tutee-prompted co-regulation, and SSMR. By highlighting the effectiveness of peer tutoring for evoking SSMR, the present dissertation moreover allowed to set out an innovative agenda for future research, given that many questions regarding the dynamic interplay between peer tutoring participants' SSMR and cognitive, communicative, or socio-emotional particularities of peers' collaboration, remain unanswered.

Additionally, the present dissertation's micro-analytical investigations of RPT-participants' ongoing interactions met the current call to clarify the effectiveness of peer tutoring formats by acknowledging the value of process data (Chi, 2009; Roscoe, 2014). More specifically, by examining and stressing the importance of RPT-groups' transactive discussions, the dissertation confirmed the need to go beyond merely identifying utterances of particular processes, demonstrated in tutors' and tutees' verbalised actions. It is additionally important to analyse sequences of tutors' and tutees' verbal exchanges (i.e. action-reaction loops) in order to comprehend the effectiveness of peer tutoring (Chi, 2009; Roscoe & Chi, 2008). The studies described in chapter 8 and 9 moreover revealed that operational transactive discussions are more beneficial for RPT-groups' adoption of particular regulation behaviour, compared to representational discussions. This finding not only confirmed the importance of reacting to each other's contributions for optimising peers' collaboration (Chi et al., 2009; Goos et al., 2002; Teasley, 1997; VanLehn et al., 2003), but also stressed the significance of the content of peers' reactions to each other. In other words, the present dissertation highlights the need to take into consideration the quality of tutors' and tutees' sequential action-reaction exchanges (e.g. do students repeat or rather elaborate each other's thinking?). Since the framework on transactivity adopted in the present dissertation was not specifically related to peer tutoring contexts, it moreover provided an instrument for identifying such quality differences in collaborative learners' interactions in a variety of settings in future research.

Apart from offering innovative insights, the present dissertation also unfolds some major challenges to be tackled in the research field on collaborative learners' (socially shared) metacognitive regulation. More specifically, three major directions for future research can be distinguished, in addition to the more concrete suggestions for future studies described above (see p. 312). First, there is a need to develop and validate a comprehensive coding instrument for interactive data analysis on collaborative learners' metacognitive regulation behaviour. Since such an instrument is not available to date (Khosa & Volet, 2014; Molenaar & Järvelä, 2014), a literature-based coding scheme to analyse RPT-participants' (socially shared) metacognitive regulation was developed as part of the present dissertation. Although this coding instrument was sensitive enough to identify and scrutinise tutors' and tutees' adoption of and initiative for key regulation skills, approaches, and foci during RPT, it is to be questioned to what extent it can be applied to other learning contexts, revealing the need for validation in future studies. One of the major challenges concerns compromising both the general and context-specific application of a coding instrument on collaborative learners' metacognitive regulation (Grau & Whitebread, 20112; Volet & Vauras, 2013). Generalizability is critical to enable comparisons of collaborative learners' (socially shared) metacognitive regulation behaviour across age groups, tasks, learning settings and different learning activities (Azevedo, 2009; Chan, 2012). On the other hand, specificity or granularity allows for closer, fine-grained coding, which is needed for the contextualised examination of the behaviour under scrutiny (Grau & Whitebread, 2012; Khosa & Volet, 2014).

Second, there is a clear need to deepen our understanding of social forms of metacognitive regulation, particularly SSMR, given that the literature on SSMR is still in its infancy. After an initial phase of empirically refining the theoretical conceptualisation of SSMR (Grau & Whitebread, 2012; Hadwin et al., 2011; Iiskala et al., 2011; Rogat & Linnenbrink-Garcia, 2011; Volet et al., 2009a), the present dissertation introduced a second research phase, directed at identifying correlates of SSMR. However, more correlational research is required to comprehend the complex interplay between collaborating students' individual characteristics, ongoing interactions, learning activities, and their involvement in shared regulative acts. Enhanced theoretical understanding in this respect will allow to purposefully design instructional interventions aimed at optimising or scaffolding collaborative learners' SSMR (Khosa & Volet, 2014; Molenaar et al., 2014; Perry & Winne, 2013). An additional challenge for future research concerns the need to empirically validate the effectiveness of SSMR for successful and productive collaborative learning (DiDonato, 2013; Molenaar & Järvelä, 2014; Rogat & Linnenbrink-Garcia, 2011; Volet et al., 2009a). Future studies should more specifically aim at examining to what extent differences in collaborative learners' SSMR contribute to differences in individual students' and the group's learning outcomes (Järvelä et al., 2013; Khosa & Volet, 2014; Rogat & Adams-Wiggins, 2014). This not only requires the inclusion of learning measures in future research designs on SSMR, but also the conceptualisation of quality differences in shared regulative acts.

Third, the present dissertation identified RPT as a fruitful environment to foster university students' metacognitive regulation. Although higher education emphasises the need for self-regulative learners more explicitly, younger students also benefit from being able to adequately regulate their learning (Annevirta & Vauras, 2006; Perry, Philips, & Dowler, 2004; Whitebread, Coltman, Pasternak, Sangester, Grau, & Bingham, 2009). Future research should therefore aim at investigating whether the metacognitive potential of RPT can also be identified in school contexts in primary or secondary education. Promoting secondary school students' metacognitive regulation might moreover facilitate the transition from secondary to higher education (Butler, 2002; Cleary & Zimmerman, 2004; Dembo & Eaton, 2000), since students would preferably be acquainted with the demands for self-regulation and self-management upon entering higher education. Implementing RPT for primary or secondary school students, aimed at fostering their (socially shared) metacognitive regulation behaviour, nevertheless also entails the challenge to train teachers in organising and supporting collaborative learning through RPT, as well as to instruct them about the importance of (socially shared) metacognitive regulation for students' learning (Cleary & Zimmerman, 2004).

Implications for educational practice and policy

The present dissertation not only extends the literature on metacognition and peer tutoring, its findings also allow advancing collaborative learners' metacognitive regulation in educational practice. Since the promotion of metacognitive regulation requires explicit modelling and guided practice (Hurme et al., 2006; Schraw et al., 2006; Schunk & Zimmerman, 2007), increasing student-staff ratios challenges higher education instructors to successfully support students in optimising their metacognitive regulation behaviour (Topping, 1996). The present dissertation demonstrated that investing time and effort in organising RPT could be a valuable alternative. A RPT-setting concerns a small-scale learning environment that allows for intensive metacognitive modelling by peers and individualised feedback on internalised regulation behaviour. Since participation in RPT benefitted both higher education students' individual and socially shared metacognitive regulation, we recommend the implementation of RPT as part of students' curriculum in higher education. Moreover, given that RPT-participants needed time and regulative practice before they started to engage in and optimise their adoption of complex regulation behaviour, such as deep-level or socially shared metacognitive regulation, higher education institutions are advised to implement RPT-interventions of a middle-long to long-term duration (e.g. organised during the course of at least one semester or preferably a complete academic year). Implementing RPT as a formal component of different courses in students' curriculum and organising RPT-sessions more frequently (e.g. twice or more in a week), might moreover intensify its beneficial impact on students' metacognitive regulation and learning, as well as facilitate the transfer of their obtained regulation behaviour to other learning situations and courses. This is an important educational objective, given the positive relationship between students' metacognitive regulation and successful academic learning (Prins et al., 2006; Schunk & Zimmerman, 2007).

The results of the present dissertation further revealed that RPT-participants did not spontaneously demonstrate a balanced engagement in different regulation skills, approaches, or foci. In other words, implementing RPT does not automatically benefit students' regulation behaviour. In contrast, educational practitioners who plan to foster students' regulative engagement by implementing RPT, are required to purposefully design learning materials that encourage students to apply particular regulation behaviour, as well as to provide students with sufficient training and intensive ongoing support to optimise their (socially shared) regulative acts. Although structuring RPT-participants' learning and interactions up to some extent (e.g. by integrating learning objectives or evaluation criteria in the RPT-learning materials, directing students' attention to particular knowledge components, learning activities, or problem solving steps) contributes to successful peer tutoring (Falchikov, 2001; King et al., 1998; Webb, 2009), educational practitioners are advised not to provide too rigid additional structure which directly shapes students' metacognitive regulation behaviour (e.g. by adding metacognitive scaffolds which explicitly instruct students to apply regulation skills as demonstrated in the scaffold). In contrast, fostering collaborative learners' (shared) regulative engagement requires students to critically discuss and reflect upon their own and peers' regulation behaviour, which can be accomplished by including problematising scaffolds in the learning materials provided to RPT-participants. It should be noted, however, that static problematising scaffolds enhanced students' (socially shared) regulative engagement only limitedly. Educational practitioners are consequently advised to provide more intensive support, which is dynamically adjusted to RPT-participants' progressive understanding of regulating collaborative learning. This is especially important for optimising students' adoption of complex regulation behaviour, such as SSMR. Intensive ongoing support should preferably be provided by an expert (e.g.

higher education lecturers). He/she could rigorously observe RPT-participants' collaboration and model how particular regulative acts, which are not spontaneously demonstrated by the RPT-participants, can be performed. Higher education lecturers are further advised to closely follow up RPT-participants throughout the RPT-intervention and to trigger their reflective transactive discussions on how to optimally regulate the RPT-group's learning. This would not only allow students to optimise their regulative engagement but might stimulate their metacognitive awareness as well (Hurme et al., 2006; Manlove et al., 2007; Schraw, 1998).

The findings of the present dissertation further highlighted the importance of training students for the RPT-intervention. Apart from instructing them about generic tutoring skills in order to successfully take the peer tutor role, educational practitioners are advised to equally prepare students for asking thought-provoking questions, providing elaborative knowledge-building explanations, and transactively reacting to each other's contributions in peer-led discussions. Fostering students' expertise in this respect is important, given the significant correlations between students' (socially shared) metacognitive regulation and their content processing strategies, and transactive discussions. In other words, the present dissertation stressed the need for a preliminary training, which is directed at successfully operating as both peer tutor and tutee.

Successfully implementing RPT as part of higher education students' curriculum, however, also requires educational policy measures (at both the macro-level and higher education institutions' policy level), which enable higher education lecturers to invest time and effort in organising and implementing RPT. Apart from assuring the presence of the necessary infrastructure (e.g. separate classrooms for separate RPT-groups, RPT-intervention-specific learning and training materials) educational policy is advised to acknowledge and meet the need for sufficient human resources, required for preparing and supervising the organisation of RPT-interventions as well as for providing ongoing support to all RPT-participants involved. Given the time- and labour-intensity of implementing RPT, policy measures should be directed at allowing and encouraging higher education lecturers to divide their time and attention between more traditional instructional approaches and RPT (e.g. by employing people who can assist higher education instructors in organising RPT or by explicitly valuing instructors' time- and effort-related investments in RPT). Policy makers are additionally encouraged to incorporate RPT as a key strategy in the professional development offer of higher education institutions. Encouraging the implementation of RPT in order to foster students' metacognitive regulation demands for training of educational practitioners, to assure that they are capable of preparing students to operate as peer tutor or tutee; of modelling and optimising metacognitive regulation, and encouraging students to act likewise; of supporting them to engage in higher-order content processing and transactive discussions; of designing learning materials which evoke and problematise regulative acts; etc. In other words, educational policy should provide time and financial means which allow educational practitioners to invest in developing and updating their own expertise, both with regard to RPT and (socially shared) metacognitive regulation (e.g. by participating in preliminary training, attending workshops, or organising reflection and feedback sessions with other RPT-organisers). It is in this respect worth mentioning the reflection-provoking potential of the coding instruments adopted in the present dissertation. Although they were initially designed to identify RPT-participants' metacognitive regulation behaviour, they might also be useful to stimulate educational practitioners' reflections on and awareness of the importance of a variety of metacognitive regulation skills, approaches, and foci. Additionally, the instruments can provide concrete criteria when evaluating instructional interventions aimed at fostering students' (socially shared) metacognitive regulation. The diverse coding categories can help educational practitioners to gain insight in students' actual versus potential regulation behaviour, informing them about the need to intensify or adapt their metacognitive modelling or scaffolding. In line with this, the coding instruments can also be adopted as reflection instruments for higher education students (e.g. integrated in the learning materials provided to RPT-participants or adopted as a general reflection tool in other learning settings). By outlining the diverse components of adequate (socially shared) metacognitive regulation behaviour, the instruments can raise students' awareness of their own engagement in particular regulation skills, approaches, or foci, and encourage them to optimise their metacognitive regulation. When integrated in RPT-learning materials, the coding instruments can further foster peer tutors' reflections on the adequacy of their metacognitive modelling behaviour, as well as provide input for RPT-groups' reflective discussions on how to optimally regulate their collaborative learning.

Below, two Tables are presented, outlining the major insights presented in this concluding chapter. Table 1 summarises the main findings for each research line within the present dissertation, in relation to their theoretical and practical implications, whereas Table 2 provides an overview of the main limitations of the present dissertation, linked to concrete suggestions for future research.

Table 1. *Summary of main findings for each research line (RL) related to their theoretical and practical implications*

RL	Main findings	Implications of main findings
1.	▪ participation in RPT does not significantly influence individual students' metacognitive knowledge; ▪ there is an important discrepancy between individual students' perceived and actual adoption of metacognitive regulation; ▪ RPT has the potential to foster individual students' actual metacognitive regulation; ▪ RPT is particularly beneficial to promote students' adoption of monitoring and (to a lesser extent) orientation and evaluation; ▪ RPT does not significantly influence students' planning; ▪ RPT fosters individual students' engagement in deep-level orientation and monitoring.	▪ there is a need for educational practitioners to foster students' metacognitive awareness; ▪ educational practitioners and policy makers are encouraged to invest time, effort, and (human) resources in the organisation and implementation of RPT to promote individual students' metacognitive regulation; ▪ the successful identification of key regulation skills and a variety of regulation strategies introduces a more complete operationalization of metacognitive regulation; ▪ the successful identification of low-level versus deep-level metacognitive regulation introduces a more in-depth operationalization of regulation; ▪ there is a need to acknowledge both the frequency of occurrence and the quality of adopted regulation behaviour when evaluating instructional interventions aimed at fostering metacognitive regulation.
2.	▪ RPT-groups demonstrate significantly increased metacognitive regulation as the RPT-intervention progresses; ▪ RPT is particularly beneficial to promote RPT-groups' adoption of orientation and evaluation; ▪ RPT does not foster RPT-groups' planning; ▪ RPT-groups dominantly apply low-level regulation but demonstrate a significant positive evolution in adopting deep-level orientation and monitoring; ▪ the adoption of orientation, planning, and evaluation in RPT-groups is dominantly initiated by the tutor, but RPT-groups demonstrate a significant positive evolution in tutee-initiated monitoring; ▪ tutees' initiative for deep-level regulation remains negligible; ▪ RPT-groups demonstrate a significant negative evolution in adopting tutor-prompted co-regulation and individually-oriented metacognitive regulation; ▪ RPT significantly fosters the adoption of tutee-prompted co-regulation and SSMR; ▪ RPT-participants need time and practice before starting to engage in SSMR;	▪ educational practitioners and policy makers are encouraged to invest time, effort, and (human) resources in the organisation and implementation of RPT to promote RPT-groups' metacognitive regulation; ▪ RPT-groups' differential engagement in and initiative for particular regulation skills, approaches, and foci reveals the need to provide differentiated support when fostering regulation, as well as the need to design learning materials that encourage students to apply particular metacognitive regulation behaviour; ▪ educational practitioners are encouraged to design middle-long to long-term RPT-interventions; ▪ educational practitioners are encouraged to intensify the RPT-experience by implementing RPT as a formal component of different courses in students' curriculum and by organising RPT on a regular base, fostering students' involvement in complex regulation behaviour and stimulating transfer of regulation; ▪ the micro-analytical process-oriented research perspective on time-bound evolutions in RPT-groups' adoption of key regulation skills, approaches, and foci extends prior, causal and output-related, research; ▪ examining the temporal dynamics of SSMR introduces a refined

	▪ the adoption of a socially shared regulation focus is particularly associated with orientation, monitoring, and deep-level metacognitive regulation.	conceptualisation of SSMR; ▪ the identification of critical change points in RPT-groups' metacognitive regulation implies a methodological innovation and allows conducting intervention studies aimed at optimally supporting collaborative learners' regulation behaviour.
3.	▪ there is no significant difference in the frequency of occurrence of key regulation skills between RPT-groups provided with structuring versus problematising scaffolds; ▪ problematising scaffolds are significantly more beneficial for evoking deep-level monitoring and tutee-initiated orientation and monitoring; ▪ structuring scaffolds are counterproductive for tutee-initiated metacognitive regulation; ▪ structuring scaffolds elicit significantly more tutor-prompted co-regulation compared to problematising scaffolds; ▪ problematising scaffolds are significantly more beneficial for evoking tutee-prompted co-regulation and SSMR compared to structuring scaffolds; ▪ problematising scaffolds reinforce RPT's natural metacognitive potential but neither scaffold type elicits a balanced engagement in metacognitive regulation skills, approaches, or foci.	▪ educational practitioners are encouraged to provide collaborative learners with problematising scaffolds that stimulate students to critically discuss and reflect upon metacognitive regulation behaviour; ▪ adequately eliciting complex regulation processes demands for intensive and calibrated support, dynamically adapted to students' progressive understanding of regulating collaborative learning; ▪ teachers or lecturers should be trained or supported to design problematising scaffolds; ▪ the designed coding instruments can be useful to problematise particular regulation behaviour or to promote students' reflections on regulation; ▪ educational practitioners are advised not to provide too rigid structure which directly shapes students' metacognitive regulation; ▪ highlighting the importance of problematising scaffolds advances the research on metacognitive scaffolds, given the dominance of structuring scaffolds in both educational research and practice.
4.	▪ RPT-groups' adoption of orientation, monitoring, and evaluation is significantly positively associated with their involvement in content processing strategies; ▪ higher-order content processing is particularly beneficial for RPT-groups' adoption of deep-level regulation and SSMR; ▪ RPT-groups' transactive discussions are significantly positively correlated with their adoption of orientation, monitoring, and SSMR; ▪ operational transactive discussions are particularly beneficial for RPT-groups' involvement in SSMR.	▪ apart from instructing students about generic tutoring skills, educational practitioners are encouraged to train RPT-participants for higher-order content processing and transactively discussing learning content and regulative acts with peers; ▪ correlational studies on RPT-groups' involvement in particular regulation skills and approaches, as well as in SSMR allow the research community to take the research to a next level by providing input for studies on the impact of instructional interventions aimed at optimising (socially shared) metacognitive regulation; ▪ the results on the impact of RPT-participants' transactive discussions highlight the need to go beyond identifying utterances of particular processes, by analysing the content of sequences of students' verbal exchanges in order to comprehend the effectiveness of RPT; ▪ the designed coding instrument allows for identifying quality differences in collaborative learners' interactions.

Table 2. *Summary of the dissertation's main limitations, related to suggestions for future research*

Limitations of the present dissertation	Concrete suggestions for future research
Research setting	
▪ the RPT-intervention was exclusively implemented in a higher education context, as a formal part of the course "Instructional Sciences"; ▪ all studies exclusively focussed on the metacognitive potential of face-to-face same-age RPT, organised in small groups; ▪ in all studies, students were provided with open-ended academic assignments aimed at deepening students' understanding of theoretical course contents; ▪ the provided ongoing support for RPT-participants was rather limited and static; ▪ the RPT-intervention was implemented for only one semester and consisted of weekly sessions of two hours each.	▪ the RPT-intervention should be implemented in other courses or study domains and for students of younger age or with a different background (e.g. freshmen natural sciences); ▪ the metacognitive potential of collaborative learning in other peer tutoring formats (e.g. cross-age or online PT), non-tutoring settings (e.g. problem-based learning), or differently composed groups (e.g. dyads or triads) should be investigated; ▪ RPT-interventions making use of alternative task formats (e.g. problem solving scripts; assignments containing closed questions; one overarching assignment to be conducted during multiple RPT-sessions) should be implemented; ▪ RPT-interventions providing more intensive support, adapted to the changing group-specific learning and regulation needs, should be organised; ▪ there is a need for long-term developmental data on students' metacognitive regulation, collected during long-lasting and more intensive RPT-interventions.
Study variables	
▪ although the group of students who participated in the RPT-intervention was not homogeneous, possible differences in RPT-participants' person-related characteristics were not acknowledged; ▪ the possible influence of group-specific particularities and dynamics was not taken into consideration; ▪ all studies were exclusively directed at RPT-participants' metacognitive regulation behaviour.	▪ individual learner characteristics should be included as mediating variables in the research design (e.g. motivation, ability, self-regulative competence, self-efficacy beliefs, academic achievement, learning style, perceptions and preferences, social status); ▪ there is a need to examine whether RPT generates a less or more beneficial impact for various learner profiles; ▪ group-specific characteristics should be included as mediating variables in the research design (e.g. socio-emotional interactions, group cohesion, synergy among group members, active listening, feedback giving, help-giving and help-seeking behaviour, equal participation, respect for peers' contributions, peers' prior relationships); ▪ output-related variables should be included in the research design (e.g. domain-specific learning gains, achievement, cognitive reasoning);

	▪ there is a need to examine whether the effects of (socially shared) metacognitive regulation on the group's learning is also applicable to individual group members.
Applied methodologies	
▪ online assessment of students' metacognitive regulation might have resulted in incomplete and biased data; ▪ the time- and labour-intensiveness of online assessment only allowed for studying small samples and the small sample sizes constrained the options to analyse the data (often resulting in non-parametric testing); ▪ by focussing on the occurrence of metacognitive regulation behaviour, the dissertation could not grasp the dynamics of RPT through which metacognitive regulation emerged; ▪ the richness of the collected video data was not fully acknowledged.	▪ there is a need for multi-method research, combining different online assessment techniques (e.g. think-aloud protocol analysis, observations, analysis of non-verbal communication, eye-tracking methodology, collecting software logged trace data); ▪ large-scale studies should be conducted, which allow acknowledging the nested structure of the data and data analysis by means of multilevel analysis; ▪ there is a need to visualise the learning and regulation processes occurring during RPT by means of social network analysis; ▪ adopting a more qualitative research perspective would be valuable (e.g. case studies with close follow-up of low- versus high-achievers/self-regulated learners, or RPT-groups poorly versus strongly sharing their regulation).

Major challenges for research

(1) development and validation of a comprehensive coding instrument for interactive analysis on collaborative learners' metacognitive regulation;

(2) deepen our insight in SSMR (i.e. more correlational research aimed at unravelling the complex interplay between collaborative learners' individual characteristics, ongoing interactions, learning activities, and socially shared regulative acts; empirical validation of the effectiveness of SSMR for successful and productive learning; conceptualisation and identification of quality differences in adopted SSMR);

(3) examination of the metacognitive potential of RPT in primary and secondary education, aimed at facilitating the transition to higher education.

Conclusion

The present dissertation aimed at examining whether participation in same-age reciprocal peer tutoring (RPT) can benefit higher education students' adoption of individual and socially shared metacognitive regulation. Four lines of research were derived from this general research aim, directed at studying the impact of RPT on the adoption of particular metacognitive regulation behaviour on the one hand, investigating the correlates of RPT-groups' metacognitive regulation on the other hand. The first research line studied individual students' adoption of key regulation skills and low-level versus deep-level regulation prior to and upon completion of a semester-long RPT-intervention. The second research line unravelled time-bound evolutions in RPT-groups' adoption of key regulation skills, a deep-level regulation approach, tutees' initiative for regulation, as well as in RPT-groups' regulative foci, particularly their socially shared metacognitive regulation (SSMR). Both research lines were intended as an initial step in investigating the metacognitive potential of RPT. Based on the obtained results, it could be concluded that RPT is a fruitful learning environment for fostering higher education students' metacognitive regulation. It should be noted, however, that RPT did not generate a balanced adoption of or initiative for metacognitive regulation skills, approaches, and foci. Participation in RPT especially advanced students' and RPT-groups' engagement in monitoring, orientation, and (albeit to a lesser extent) evaluation. Despite significantly increased deep-level and tutee-initiated regulation, RPT-participants demonstrated a dominant involvement in low-level and tutor-initiated regulative acts. Additionally, the second research line revealed that RPT was particularly beneficial towards evoking tutee-prompted co-regulation and SSMR.

Whereas the first and second research line examined RPT's natural strength to encourage students into particular metacognitive regulation behaviour, the third research line studied whether providing RPT-groups with structuring versus problematising metacognitive scaffolds optimised their regulative engagement. The results revealed that problematising scaffolds were significantly more beneficial for eliciting deep-level regulation, tutee-initiated regulative acts, tutee-prompted co-regulation, as well as SSMR, compared to structuring scaffolds. It should be noted, however, that problematising scaffolds merely reinforced RPT's natural potential to foster particular regulation behaviour but appeared less appropriate to elicit regulative acts which were less spontaneously applied. Encouraging students' adoption of complex regulation behaviour consequently requires intensive and calibrated support.

Last, the fourth research line aimed at advancing our understanding of collaborative learners' metacognitive regulation in relation to the underlying dynamics of the collaborative learning process. It more specifically examined the relationship between RPT-groups' adoption of metacognitive regulation and their content processing strategies, and the level of transactivity in peers' discussions. Based on the obtained results, it can be concluded that particularly higher-order content processing and operational transactive discussions are important when promoting RPT-participants' (deep-level and socially shared) metacognitive regulation.

By analysing RPT-participants' metacognitive regulation through direct observation of their diversified regulation behaviour in a process-oriented way, the present dissertation contributes innovative insights to the literature on metacognitive regulation in collaborative settings. Its limitations further unfold interesting challenges to be tackled in future research. Researchers are particularly encouraged to study the impact of collaborative learners' differentiated engagement in SSMR on individual students' and the group's leaning. Further, given the positive results revealed in the present dissertation, educational practitioners and policymakers are encouraged to promote higher education students' metacognitive regulation by investing time and effort in organising RPT.

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Nederlandstalige samenvatting

Summary in Dutch

Nederlandstalige samenvatting

Het bevorderen van individuele en sociaal gedeelde metacognitieve regulatie bij universiteitsstudenten door middel van reciproke same-age peer tutoring: Een studie naar de impact en interactieprocessen

Inleiding

Studenten opleiden in de hedendaagse kennismaatschappij vraagt om competentiegericht, levenslang en zelfgestuurd leren (Bruinsma, 2004; MacLellan & Soden, 2006; Perry & Winne, 2013). De voorbije decennia is bijgevolg een verschuiving merkbaar in het onderwijs van kennisoverdracht naar actieve en zelfstandige kennisconstructie door studenten (Barron, 2003; Topping, 2005; Zimmerman & Schunk, 2011). Succesvol en betekenisvol leren vraagt vanuit dit perspectief om het gebruik van metacognitieve kennis en metacognitieve regulatie (Azevedo, 2009; Nota, Soresi, & Zimmerman, 2004; Pintrich, 2004; Veenman, van Hout-Wolters, & Afflerbach, 2006). Metacognitieve kennis verwijst naar de kennis die de lerende heeft over zichzelf en anderen als cognitieve verwerkers van informatie, alsook over de selectie en het gebruik van adequate cognitieve strategieën met het oog op het bereiken van vooropgestelde leerdoelen binnen een specifieke leercontext (Brown, 1987; Pintrich, 2004; Schraw, 1998). Metacognitieve regulatie verwijst naar het geheel van zelfregulerende vaardigheden en strategieën die door de lerende worden aangewend om cognitieve activiteiten en processen op actieve en adaptieve wijze te controleren, manipuleren en optimaliseren (Azevedo, 2009; Hadwin, Järvelä, & Miller, 2011; Meijer, Veenman, & van Hout-Wolters, 2006). In dit proefschrift onderscheiden we oriënteren, plannen, monitoren en evalueren als metacognitieve basisregulatievaardigheden (Brown, 1987; Meijer et al., 2006; Winne, 2011). Oriënteren is gericht op het voorbereiden van de te ondernemen cognitieve activiteiten (Meijer et al., 2006). Tijdens het oriënteren neemt de lerende idealiter de gegeven leertaak in beschouwing, reflecteert hij over de gepercipieerde moeilijkheid ervan en activeert hij voorkennis (Butler, 2002; Pintrich, 2002). Plannen verwijst naar het oplijsten en selecteren van te ondernemen stappen of te doorlopen activiteiten met het oog op het bereiken van gestelde leerdoelen (Bannert & Mengelkamp, 2008; Brown, 1987; Meijer et al., 2006). Monitoren is gericht op het bewaken van het kennisbegrip, de adequaatheid van gehanteerde leerstrategieën en de kwaliteit van gemaakte vooruitgang in functie van vooropgestelde leerdoelen (Brown, 1987; Moos & Azevedo, 2009; Winne, 2011). Ingeval van vastgestelde hiaten in dit verband resulteert monitoring in het modificeren van leeractiviteiten. Tijdens het evalueren controleert en reflecteert de lerende over zowel de leeruitkomsten als over het doorlopen leerproces (Butler, 2002; Meijer et al., 2006).

Onderzoek toont aan dat met name metacognitieve regulatie bijdraagt tot een uitgebreider en meer diepgaand kennisbegrip, actieve verwerking van de leerinhoud en verbeterde leerprestaties (Azevedo, 2009; Pintrich, 2004; Veenman et al., 2006; Winne, 2011). Met name in het hoger onderwijs wordt het gebruik van metacognitieve regulatievaardigheden belangrijk geacht voor academisch succes. Zowel organisatorisch als inhoudelijk wordt van studenten in het hoger onderwijs immers verwacht dat ze het eigen leerproces zelfstandig kunnen vormgeven, controleren en bijsturen (Bruinsma, 2004; Nota et al., 2004). Onderzoek wijst echter uit dat zij vaak over onvoldoende metacognitieve regulatievaardigheden beschikken om het eigen leren daadwerkelijk op adequate wijze te kunnen reguleren (MacLellan & Soden, 2006; Nota et al., 2004). Het bevorderen van metacognitieve regulatie bij studenten in het hoger onderwijs vormt bijgevolg een belangrijk onderwijsdoel.

Recente onderzoeksliteratuur omtrent metacognitie beklemtoont de meerwaarde van collaboratief leren voor het bevorderen van metacognitieve regulatie (Hadwin et al., 2011; Järvelä, Järvenojä, Malmberg, & Hadwin, 2013; Vauras & Volet, 2013). Collaboratief leren faciliteert niet louter het aanwenden, oefenen en verfijnen van metacognitieve regulatievaardigheden door individuele studenten, het stimuleert hen ook tot betrokkenheid in sociale vormen van metacognitieve regulatie, zoals co-regulatie en sociaal gedeelde metacognitieve regulatie met meerdere peers (Hurme, Palonen, & Järvelä, 2006; Iiskala, Vauras, & Lehtinen, & Salonen, 2011; Rogat & Linnenbrink-Garcia, 2011; Schraw, Crippen, & Hartley, 2006; Volet, Summers, & Thurman, 2009a). Metacognitieve co-regulatie wordt gekenmerkt door een asymmetrisch engagement van studenten ten aanzien van het regulatieproces: één student (i.e. de co-regulator) neemt een directieve rol op zich en moedigt andere studenten aan tot het aanwenden van metacognitieve regulatievaardigheden (Hadwin, Wozney, & Pontin, 2005; Rogat & Adams-Wiggins, 2014; Perry & Winne, 2013). Sociaal gedeelde metacognitieve regulatie wordt daarentegen gekarakteriseerd door een wederzijdse en gelijkwaardige betrokkenheid van verschillende studenten in het regulatieproces (Grau & Whitebread, 2012; Iiskala et al., 2011; Volet, Vauras, & Salonen, 2009b). Hoewel het geïnitieerd wordt door de regulatieactiviteiten van een individuele student, wordt sociaal gedeelde metacognitieve regulatie vormgegeven door daaropvolgende reciproke metacognitieve bijdragen van meerdere studenten, die inspelen op elkaars metacognitieve regulatieactiviteiten en bijgevolg het regulatieproces delen (Järvelä et al., 2013; Khosa & Volet, 2014; Rogat & Linnenbrink-Garcia, 2011). Met name sociaal gedeelde metacognitieve regulatie draagt bij tot succesvol en productief collaboratief leren (Chan, 2012; Iiskala et al., 2011; Volet et al., 2009a).

Niettegenstaande het metacognitieve potentieel van collaboratief leren in toenemende mate wordt erkend, werd tot op heden weinig procesgericht onderzoek gevoerd naar de onderliggende dynamieken en interacties tussen studenten, die het aanwenden van metacognitieve regulatievaardigheden tijdens collaboratief leren kunnen verklaren (Hadwin et al., 2011; Molenaar & Järvelä, 2014; Vauras & Volet, 2013). Dergelijk onderzoek is echter nodig om het metacognitief potentieel van collaboratief leren te begrijpen en te optimaliseren. Deze doctoraatsstudie tracht daarom te onderzoeken en te verklaren waarom deelname aan reciproke same-age peer tutoring waardevol kan zijn om de individuele en sociaal gedeelde metacognitieve regulatie van universiteitsstudenten te bevorderen.

Peer tutoring is een specifieke vorm van collaboratief leren, gericht op de actieve verwerving van kennis en vaardigheden via zorgvuldig georganiseerde en gedeeltelijk gestructureerde samenwerking tussen peers in kleine groepen of leerparen (Duran & Monereo, 2005; Falchikov, 2001; King, 1998; Topping, 2005). Peer tutoring wordt gekenmerkt door specifieke rolinname van de betrokken studenten als peer tutor of tutee (Falchikov, 2001; Topping, 2005). Studenten in de tutorrol beschikken over meer kennis en expertise (hetzij van nature uit, hetzij omdat ze extra bronnen ter beschikking krijgen) en nemen van daaruit een ondersteunende rol op binnen de peergroep, via het stimuleren van kennisconstructie en reflectie, het bieden van verduidelijking en het actief scaffolden van leer- en regulatieprocessen. De minder ervaren studenten die cognitief uitgedaagd en begeleid worden door de peer tutor, nemen de rol op van 'tutees'. Same-age peer tutoring is een specifieke variant van peer tutoring waarbij participanten worden gerekruteerd uit dezelfde klasgroep, waardoor tutor en tutees over vergelijkbare kennis en vaardigheden beschikken bij aanvang van de peer tutoringinterventie (Falchikov, 2001; Topping, 2005). Reciproke peer tutoring (RPT) wordt gekarakteriseerd door het beurtelings wisselen van de tutorrol tussen studenten van de peergroep en geeft iedere participant bijgevolg de kans om zowel de tutor- als de tuteerol op zich te nemen en de specifieke voordelen en uitdagingen, verbonden aan beide rollen, te ervaren (Duran & Monereo, 2005; Topping, 1996). Dit proefschrift gaat in het bijzonder na of participatie in same-age RPT het metacognitief regulatiegedrag van studenten in het hoger onderwijs kan promoten. Het gaat daarbij meer specifiek uit van een procesgerichte analyse van collaboratieve leer- en metacognitieve regulatieactiviteiten.

Onderzoekslijnen

Het doctoraatsonderzoek werd vormgegeven op basis van vier onderzoekslijnen, gericht op enerzijds het bestuderen van de impact van RPT op het aanwenden van specifiek metacognitief regulatiegedrag, anderzijds het identificeren van de correlaten van het metacognitief regulatiegedrag van RPT-groepen. Een eerste onderzoekslijn ging na welke impact deelname aan RPT genereerde op de metacognitieve regulatie van individuele studenten, door hun gebruik van metacognitieve regulatie voor aanvang en na afloop van een RPT-interventie te meten. Binnen de eerste onderzoekslijn werden twee onderzoeksdoelen onderscheiden, met name:

- OD 1.1: onderzoeken van de impact van RPT op de metacognitieve kennis, het gepercipieerde gebruik van metacognitieve regulatievaardigheden en het reële gebruik van metacognitieve regulatievaardigheden van individuele studenten;
- OD 1.2: onderzoeken van de impact van RPT op het reële gebruik van metacognitieve regulatievaardigheden en diepgaande metacognitieve regulatie door individuele studenten.

Niettegenstaande voorgaand onderzoek aantoonde dat peer tutoring het aanwenden van metacognitieve monitoring kan bevorderen (King, Staffieri, & Adelgais, 1998; Roscoe, 2014), zijn bevindingen omtrent de impact van peer tutoring in het algemeen, RPT in het bijzonder, op het gebruik van andere regulatievaardigheden niet voorhanden. De eerste onderzoekslijn trachtte inzichten uit voorgaand onderzoek daarom uit te breiden door uit te gaan van een integraal perspectief op metacognitie. Naast het inventariseren van de effecten van deelname aan RPT op de metacognitieve kennis van individuele studenten, ging de aandacht bijkomend uit naar de impact op hun gebruik van alle basisregulatievaardigheden (i.e. oriënteren, plannen, monitoren en evalueren), alsook op hun gebruik van oppervlakkige versus diepgaande regulatiestrategieën. De eerste onderzoekslijn dient bijgevolg gepercipieerd te worden als een initiële stap in het onderzoeken van het metacognitief potentieel van RPT.

Aanvullend op de focus op het regulatiegebruik van individuele studenten in de eerste onderzoekslijn, onderzocht de tweede onderzoekslijn welke impact RPT genereerde op het aanwenden van metacognitieve regulatie binnen de RPT-groepen. De aandacht ging meer specifiek uit naar het ontrafelen van tijdgebonden evoluties in het metacognitief regulatiegedrag van RPT-groepen, via gedetailleerde analyse van de interacties tussen RPT-participanten. Binnen de tweede onderzoekslijn werden twee onderzoeksdoelen onderscheiden, met name:

OD 2.1: analyseren van tijdgebonden evoluties in het gebruik van basisregulatievaardigheden, diepgaande metacognitieve regulatie en tutee-geïnitieerde regulatie binnen RPT-groepen;

OD 2.2: analyseren van tijdgebonden evoluties in het gebruik van individueel georiënteerde metacognitieve regulatie, co-regulatie en sociaal gedeelde metacognitieve regulatie binnen RPT-groepen.

De tweede onderzoekslijn beoogde diepgaand inzicht te verwerven in het metacognitief regulatiegedrag van collaboratieve lerenden. De micro-analytische focus op regulatieve interacties tussen tutors en tutees, evenals het in kaart brengen van de regulatiefoci (i.e. individueel georiënteerde, co- en sociaal gedeelde metacognitieve regulatie) van RPT-groepen impliceerden een innovatieve bijdrage aan de onderzoeksliteratuur omtrent metacognitieve regulatie in collaboratieve settings.

De eerste en tweede onderzoekslijn analyseerden het natuurlijk metacognitief potentieel van RPT. De derde onderzoekslijn bestudeerde daarentegen of en hoe dergelijk natuurlijk uitgelokt metacognitief regulatiegedrag binnen RPT-groepen geoptimaliseerd kan worden door studenten metacognitieve scaffolds aan te reiken. Binnen de derde onderzoekslijn werden twee onderzoeksdoelen onderscheiden, met name:

OD 3.1: onderzoeken welke impact structurerende versus problematiserende scaffolds genereren op het gebruik van basisregulatievaardigheden, diepgaande metacognitieve regulatie en tutee-geïnitieerde regulatie binnen RPT-groepen;

OD 3.2: onderzoeken welke impact structurerende versus problematiserende scaffolds genereren op het aanwenden van co-regulatie en sociaal gedeelde metacognitieve regulatie binnen RPT-groepen.

De derde onderzoekslijn trachtte bij te dragen aan hiaten in de onderzoeksliteratuur betreffende metacognitieve scaffolds. Tot op heden zijn immers weinig empirische resultaten beschikbaar over hoe specifiek metacognitief regulatiegedrag (bv. basisregulatievaardigheden, diepgaande regulatiestrategieën of sociale vormen van metacognitieve regulatie) optimaal ondersteund kan worden. Met name de studie betreffende de impact van metacognitieve scaffolds op de betrokkenheid van RPT-participanten in sociaal gedeelde metacognitieve regulatie droeg vernieuwende inzichten bij, gezien het innovatieve karakter van het onderzoeksdomein rond sociaal gedeelde metacognitieve regulatie (Molenaar & Järvelä, 2014; Vauras & Volet, 2013).

In tegenstelling tot de andere onderzoekslijnen focuste de vierde onderzoekslijn niet op de metacognitieve impact van RPT maar ging de aandacht uit naar het identificeren van de correlaten van het metacognitief regulatiegedrag van RPT-groepen. Binnen de vierde onderzoekslijn werden twee onderzoeksdoelen onderscheiden, met name:

OD 4.1: analyseren van de relatie tussen het aanwenden van basisregulatievaardigheden en diepgaande metacognitieve regulatie binnen RPT-groepen en hun kennisverwerkingsstrategieën enerzijds, de mate van transactiviteit in hun peerdiscussies anderzijds;

OD 4.2: analyseren van de relatie tussen het aanwenden van sociaal gedeelde metacognitieve regulatie binnen RPT-groepen en hun kennisverwerkingsstrategieën enerzijds, de mate van transactiviteit in hun peerdiscussies anderzijds.

Door het metacognitief regulatiegebruik van RPT-groepen in relatie te brengen met onderliggende dynamieken en kenmerken van het collaboratief leerproces, trachtte de vierde onderzoekslijn het metacognitief potentieel van RPT (vastgesteld in de vorige onderzoekslijnen) te verklaren.

Overzicht van de hoofdbevindingen

Onderzoekslijn 1: Bestuderen van de impact van participatie aan RPT op de metacognitieve regulatie van individuele studenten

In de eerste onderzoekslijn lag de nadruk op het analyseren van veranderingen in het metacognitief regulatiegebruik van individuele RPT-participanten na deelname aan RPT. Twee empirische studies, gepresenteerd in hoofdstukken 2 en 3, maakten deel uit van deze onderzoekslijn. Hoofdstuk 2 rapporteert over een studie waarbij 67 Schakelstudenten Pedagogische Wetenschappen gedurende een volledig semester participeerden als tutor en tutee in een RPT-interventie. Voor aanvang en na afloop van de RPT-interventie werden de metacognitieve kennis en het gepercipieerde regulatiegebruik van alle participanten gemeten aan de hand van een zelfrapportage-vragenlijst (i.e. Metacognitive Awareness Inventory, Schraw & Dennisson, 1994), terwijl hun reële metacognitieve regulatiegebruik in kaart werd gebracht via analyse van hardop-denkprotocollen, verzameld tijdens de uitvoering van een individuele academische leertaak (Bannert & Mengelkamp, 2008; Greene, Robertson, & Croker Costa, 2011). Aan de hand van paired-samples t-testen werden veranderingen in metacognitie van pretest naar posttest onderzocht. De resultaten wezen uit dat studenten hun metacognitieve kennis, evenals hun gepercipieerd gebruik van metacognitieve regulatievaardigheden hoog inschatten op beide meetmomenten. Er werden bovendien geen significante verschillen vastgesteld in metacognitieve kennis en gepercipieerde metacognitieve regulatie voor aanvang en na afloop van de RPT-interventie. Analyse van de hardop-denkprotocollen legde echter een discrepantie bloot tussen het gepercipieerde en het reële gebruik van metacognitieve regulatievaardigheden. Hoewel studenten frequent gebruik maakten van monitoring, zowel tijdens de pretest- als de posttestmeting, wendden ze de andere basisregulatievaardigheden aanzienlijk minder aan dan gerapporteerd, vooral tijdens de pretest. Hoofdstuk 2 toonde bijkomend een significante toename in het reëel gebruik van monitoring, oriënteren en evalueren na afloop van de RPT-interventie. Studenten wendden deze regulatievaardigheden niet louter frequenter aan, maar lieten bovendien een meer gevarieerd gebruik van regulatiestrategieën optekenen. Een significante verandering in hun plangedrag kon niet worden vastgesteld.

De studie waarover wordt gerapporteerd in hoofdstuk 3, werd opgezet met zowel de resultaten als de beperkingen van de eerste studie (hoofdstuk 2) in het achterhoofd. Aangezien RPT geen significante impact op de metacognitieve kennis van studenten leek te genereren en zelfrapportage-vragenlijsten inadequaat bleken om het metacognitief regulatiegebruik accuraat te meten, focuste de studie in hoofdstuk 3 exclusief op het in kaart brengen van veranderingen in de reële metacognitieve regulatie van studenten na deelname aan een RPT-interventie, aan de hand van analyse van hardop-denkprotocollen. Er werd een quasi-experimenteel pretest-posttest onderzoeksdesign opgezet, waarin 64 Schakelstudenten Pedagogische Wetenschappen deelnamen als experimentele groep, die gedurende een volledig semester participeerden aan een RPT-interventie. Een eerste controlegroep bestond uit 24 Eerstejaarsstudenten Pedagogische Wetenschappen. Zij doorliepen een gelijkaardig curriculum als studenten van de experimentele groep maar verschilden van laatstgenoemde wat betreft hun ervaring in het hoger onderwijs. Een tweede controlegroep bestond uit 21 Schakelstudenten Sociaal Werk, wiens curriculum verschilde van dat van de studenten uit de experimentele en de eerste controlegroep. De experimentele en tweede controlegroep vertoonden dan weer gelijkenissen in voorgaande ervaringen in het hoger onderwijs. Aan het begin en op het einde van het semester werd de metacognitieve regulatie van alle deelnemers aan de studie concurrent gemeten tijdens de uitvoering van een individuele academische leertaak, waarvan het oplossingsproces geverbaliseerd diende te worden. Analyse van de resulterende hardop-denkprotocollen bood inzicht in het gebruik van basisregulatievaardigheden en oppervlakkige versus diepgaande regulatiestrategieën door de studenten. De impact van RPT op het metacognitief regulatiegebruik werd gemeten met behulp van mixed ANOVA's. Hoofdstuk 3 toonde een significante toename in het aanwenden van monitoring (i.e. van zowel begrip als voortgang), evalueren (i.e. van leeruitkomsten) en oriënteren (i.e. taakanalyse) voor de experimentele groep. Bijkomend kon significant toegenomen gebruik van diepgaande regulatiestrategieën (i.e. monitoring) gerapporteerd worden voor de experimentele groep. Met uitzondering van een significant gestegen engagement ten aanzien van oppervlakkige begripsmonitoring, werden geen van de bovengenoemde veranderingen waargenomen bij studenten uit de controlegroepen. Het planningsgedrag van studenten kende geen significante verandering van pretest naar posttest, voor geen van de betrokken onderzoeksgroepen.

Samenvattend kunnen op basis van de bevindingen uit de eerste onderzoekslijn drie belangrijke conclusies getrokken worden. Ten eerste heerste een discrepantie tussen het gepercipieerde en het reële gebruik van metacognitieve regulatie door studenten hoger onderwijs. Het overschatte gepercipieerde regulatiegebruik legt niet enkel een hypotheek op succesvol en betekenisvol (zelfregulerend) leren (Pintrich, 2002; Winne & Jamieson-Noel, 2002), maar maakt ook de nood aan initiatieven ter bevordering van het metacognitief bewustzijn van studenten in het hoger onderwijs duidelijk (MacLellan & Soden, 2006; Schraw, 1998). Ten tweede kan gesteld worden dat deelname aan RPT een positieve impact genereerde op het aanwenden van metacognitieve regulatie. RPT resulteerde echter niet in een evenwichtig gebruik van diverse metacognitieve regulatievaardigheden en -strategieën. Hoewel het de betrokkenheid van studenten in monitoring aanzienlijk bevorderde, bleek de impact van RPT op oriënteren en evalueren beduidend kleiner, terwijl voor plannen geen significante invloed kon worden opgetekend. Ten derde slaagde de eerste onderzoekslijn erin oppervlakkige van diepgaande regulatiestrategieën te onderscheiden. Daardoor wordt niet louter een meer diepgaande operationalisering van metacognitieve regulatie geïntroduceerd, maar wordt tevens de meerwaarde van het erkennen van kwaliteitsverschillen in aangewende metacognitieve regulatiestrategieën bevestigd (Rogat & Linnenbrink-Garcia, 2011; Zimmerman & Schunk, 2011).

Onderzoekslijn 2: Bestuderen van de impact van RPT op de metacognitieve regulatie van RPT-groepen

In navolging van de eerste onderzoekslijn die de impact van RPT op het regulatiegedrag van individuele studenten onderzocht, analyseerde de tweede onderzoekslijn of het tutoren van medestudenten een positieve impact genereerde op het metacognitief regulatiegebruik van RPT-groepen. De nadruk lag meer specifiek op het in kaart brengen van tijdgebonden evoluties in het gebruik van basisregulatievaardigheden, diepgaande regulatiestrategieën, tutee-geïnitieerde regulatie, en regulatiefoci (i.e. individueel georiënteerde, co-, en sociaal gedeelde regulatie) binnen de RPT-groepen. Een toename in dit verband werd geïnterpreteerd als een positieve impact van RPT. Twee empirische studies, gerapporteerd in hoofdstukken 4 en 5, maakten deel uit van de tweede onderzoekslijn. In het kader van beide studies participeerden 64 Schakelstudenten Pedagogische Wetenschappen aan een semesterlange RPT-interventie, waarin zij elkaar tutorden in vaste groepjes van zes studenten. Alle RPT-sessies van vijf at random geselecteerde RPT-groepen (30 studenten) werden integraal opgenomen op video. Het metacognitief regulatiegebruik werd gemeten door observatie van de geverbaliseerde interacties tussen RPT-participanten. Om evoluties in het metacognitief regulatiegedrag van de RPT-groepen in kaart te brengen, werden mixed models voor logistische regressieanalyse met change points gebruikt.

Hoofdstuk 4 onthulde een significant positieve evolutie in het gebruik van metacognitieve regulatievaardigheden door de RPT-groepen. De grootste toename werd opgetekend voor oriënteren (i.e. voorkennis activeren) en evalueren (i.e. van zowel leeruitkomsten als van het leerproces).

Beiden werden bovendien reeds tijdens de eerste helft van de RPT-interventie significant frequenter aangewend. In navolging van de studies naar de impact van RPT op de metacognitieve regulatie van individuele studenten (onderzoekslijn 1), kon geen significante evolutie in het plangedrag van RPT-groepen worden gerapporteerd. De resultaten wezen verder uit dat RPT-groepen voornamelijk oppervlakkige regulatiestrategieën aanwendden gedurende de volledige RPT-interventie. Hun gebruik van diepgaande oriëntering- en monitoringstrategieën nam echter significant toe in de loop van de eerste RPT-interventiehelft. Voorts maakte hoofdstuk 4 duidelijk dat tutees het gebruik van monitoring in de RPT-groepen significant frequenter initieerden vanaf de voorlaatste RPT-sessie. Het initiatief voor oriënteren, plannen en evalueren bleef daarentegen gedurende de hele interventieduur voornamelijk van de tutor uitgaan. Ook het tutee-initiatief voor diepgaande regulatiestrategieën bleef beperkt.

De studie gerapporteerd in hoofdstuk 5 onderzocht evoluties in het gebruik van individueel georiënteerde metacognitieve regulatie, co-regulatie en sociaal gedeelde metacognitieve regulatie binnen RPT-groepen. De resultaten toonden aan dat bij aanvang van de RPT-interventie het metacognitief regulatiegedrag van de RPT-groepen voornamelijk werd gekenmerkt door tutor-gecentreerde co-regulatie: vanuit hun functie als metacognitief model moedigden tutors de tutees expliciet aan tot engagement in bepaalde regulatievaardigheden. Tegelijk bleven tutee-gecentreerde co-regulatie en sociaal gedeelde metacognitieve regulatie beperkt tijdens deze aanvangsfase. Naarmate de RPT-sessies vorderden, daalden zowel tutor-gecentreerde co-regulatie als individueel georiënteerde metacognitieve regulatie significant. Het gebruik van tutee-gecentreerde co-regulatie en sociaal gedeelde metacognitieve regulatie nam daarentegen significant toe binnen de RPT-groepen. Dit resultaat wijst erop dat naarmate tutees meer expertise opdoen in de RPT-setting, zij geleidelijk meer bijdragen aan de regulatie van het collaboratief leerproces. Er dient evenwel opgemerkt dat sociaal gedeelde metacognitieve regulatie pas in de tweede helft van de RPT-interventie significant toenam. Studenten bleken bijgevolg tijd nodig te hebben om ervaring op te doen alvorens zich te engageren in complexe regulatieactiviteiten als sociaal gedeelde metacognitieve regulatie. Hoofdstuk 5 toonde verder aan dat het aanwenden van sociaal gedeelde metacognitieve regulatie significant positief geassocieerd is met oriënteren en monitoren. Plannen en evalueren worden daarentegen nauwelijks sociaal gedeeld. Ook het gebruik van diepgaande regulatiestrategieën moedigde RPT-participanten aan tot sociaal gedeelde metacognitieve regulatie.

Samenvattend kunnen op basis van de tweede onderzoekslijn drie belangrijke conclusies getrokken worden. Ten eerste werd gewezen op het potentieel van RPT om tutors en tutees in toenemende mate te betrekken in metacognitieve regulatie. Participatie in RPT bleek met name voordelig voor het gebruik van oriëntering, evaluatie, diepgaande monitoring, tutee-gecentreerde co-regulatie en sociaal gedeelde metacognitieve regulatie. Er dient evenwel opgemerkt te worden dat uiteenlopende evolutiepatronen werden vastgesteld in het gebruik van en initiatief voor specifieke regulatievaardigheden, diepgaande regulatiestrategieën en verschillende regulatiefoci. De tweede onderzoekslijn onderschrijft bijgevolg de nood aan gedifferentieerde ondersteuning bij het promoten van metacognitief regulatiegedrag. Bijkomend dient op basis van de bekomende resultaten ook te worden gepleit voor middellange tot langdurige RPT-interventies, gezien studenten zich pas tijdens de tweede helft van de RPT-interventie engageerden in complex regulatiegedrag. Ten tweede bleek niet zozeer de frequentie van voorkomen van regulatiegedrag doorslaggevend voor het aanwenden van diepgaande regulatiestrategieën maar eerder de eigenheid van metacognitieve regulatievaardigheden. Met name het uitlokken van socio-cognitieve conflicten tijdens het expliciteren van verschillen in het kennisbegrip van RPT-participanten (i.e. tijdens activering van voorkennis of begripsmonitoring) leek in dit verband belangrijk. Ten derde kan op basis van de eerste en de tweede onderzoekslijn geconcludeerd worden dat het gebruik van metacognitieve regulatie deels context-specifiek is. Afhankelijk van de individuele versus sociale context (in respectievelijk de eerste en tweede onderzoekslijn) waarin studenten regulatievaardigheden aanwendden, demonstreerden zij immers andere regulatiestrategieën.

Onderzoekslijn 3: Bestuderen van de impact van metacognitieve scaffolds op het metacognitief regulatiegedrag van RPT-groepen

Hoewel de eerste en tweede onderzoekslijn het metacognitief potentieel van RPT beklemtoonden resulteerde participatie aan RPT niet in een evenwichtig gebruik van diverse regulatievaardigheden, diepgaande regulatiestrategieën of verschillende regulatiefoci. De derde onderzoekslijn trachtte daarom te onderzoeken of het natuurlijk metacognitief potentieel van RPT kan worden bevorderd door RPT-participanten structurerende of problematiserende metacognitieve scaffolds aan te reiken. Er werden twee empirische studies opgezet, beschreven in hoofdstukken 6 en 7, met het oog op het identificeren van het meest effectieve type scaffolds. In het kader van beide studies participeerden 58 Schakelstudenten Pedagogische Wetenschappen aan een semesterlange RPT-interventie in vaste groepen van 6 studenten. Beide studies werden gekenmerkt door een quasi-experimenteel onderzoeksopzet waarin twee experimentele condities onderscheiden werden: de structurerende scaffoldconditie en de problematiserende scaffoldconditie. RPT-groepen in de eerste conditie kregen scaffolds die hen op directe wijze aanspoorden tot het aanwenden van metacognitieve regulatievaardigheden, zoals gedemonstreerd in de scaffolds (Molenaar, Sleegers, & van Boxtel, 2014; Reiser, 2004). RPT-groepen in de problematiserende conditie ontvingen daarentegen scaffolds die hen aanmoedigden te reflecteren over louter gesuggereerde metacognitieve regulatievaardigheden. De eerste (bij aanvang), derde (halverwege) en zesde (voorlaatste) RPT-sessie van acht at random geselecteerde RPT-groepen (vier uit de structurerende conditie en vier uit de problematiserende conditie) werden integraal opgenomen op video. Het metacognitief regulatiegedrag van alle RPT-groepen werd gemeten door observatie van de geverbaliseerde interacties tussen RPT-participanten.

De studie waarover gerapporteerd wordt in hoofdstuk 6 onderzocht de impact van structurerende versus problematiserende scaffolds op het gebruik van basisregulatievaardigheden, diepgaande regulatiestrategieën en tutee-geïnitieerde regulatie aan de hand van mixed ANOVA's. De resultaten wezen uit dat RPT-groepen in beide scaffoldcondities significant frequenter gebruik maakten van basisregulatievaardigheden naarmate de RPT-sessies vorderden, maar dat geen van beide types scaffolds significant voordeliger bleek voor het uitlokken van oriënteren, plannen, monitoren of evalueren. Problematiserende scaffolds genereerden daarentegen een significant grotere toename in diepgaande monitoringstrategieën in vergelijking met structurerende scaffolds. Beide scaffoldcondities verschilden echter niet significant van elkaar in het gebruik van diepgaande oriëntering-, plan- of evaluatiestrategieën. Verder bleken problematiserende scaffolds significant voordeliger dan structurerende scaffolds voor het uitlokken van tutee-geïnitieerde oriëntering en monitoring. Tutee-geïnitieerde planning en evaluatie werden daarentegen door geen van beide types scaffolds positief beïnvloed.

In hoofdstuk 7 werd onderzocht of structurerende versus problematiserende scaffolds een differentiële impact genereerden op het gebruik van co-regulatie enerzijds, sociaal gedeelde metacognitieve regulatie anderzijds. Daartoe werden Mann Whitney U-testen gehanteerd. Bijkomend werd aan de hand van binaire logistische regressies nagegaan of RPT-groepen in beide scaffoldcondities andere evoluties demonstreerden in het gebruik van bovengenoemde sociale vormen van metacognitieve regulatie. De resultaten toonden aan dat structurerende scaffolds significant meer tutee-gecentreerde co-regulatie uitlokten in vergelijking met problematiserende scaffolds, terwijl laatstgenoemden het gebruik van tutee-gecentreerde co-regulatie significant meer deden toenemen, vergeleken met structurerende scaffolds. Niettegenstaande het directieve karakter van structurerende scaffolds van nature uit nauwer lijkt aan te sluiten bij de pedagogische verantwoordelijkheid van de tutor, demonstreerden RPT-groepen in de structurerende scaffoldconditie positieve evoluties in zowel tutor-gecentreerde als tutee-gecentreerde co-regulatie (al was laatstgenoemde minder uitgesproken in vergelijking met RPT-groepen in de problematiserende scaffoldconditie). Dit resultaat benadrukt de natuurlijke kracht van RPT om tutees in toenemende mate te betrekken in de metacognitieve regulatieactiviteiten binnen de RPT-groep. Hoofdstuk 7 toonde verder aan dat RPT-groepen die problematiserende scaffolds kregen aangereikt, evolueerden naar een significant toegenomen engagement in sociaal gedeelde metacognitieve regulatie. Problematiserende scaffolds bleken ook significant meer sociaal gedeelde regulatie uit te lokken vergeleken met structurerende scaffolds. De voordelige impact van problematiserende scaffolds kon echter enkel worden gerapporteerd voor de zesde RPT-sessie. Dit impliceert dat studenten tijd nodig hadden om zich te engageren in complexe regulatiegedragingen als sociaal gedeelde metacognitieve regulatie en dat metacognitieve scaffolds pas voordelig kunnen zijn wanneer studenten voldoende vaardig zijn in dat verband.

Samenvattend kunnen op basis van de derde onderzoekslijn twee belangrijke conclusies getrokken worden. Ten eerste kan geconcludeerd worden dat problematiserende scaffolds het meest voordelig zijn voor het uitlokken van diepgaande regulatiestrategieën, tutee-geïnitieerde regulatieactiviteiten, tutee-gecentreerde co-regulatie en sociaal gedeelde metacognitieve regulatie. Dit betreft een belangrijke bevinding gezien zowel de onderwijspraktijk als onderwijskundig onderzoek gekenmerkt worden door een dominante implementatie van structurerende scaffolds (Molenaar et al., 2014; Reiser, 2004). Ten tweede dient op basis van de derde onderzoekslijn opgemerkt te worden dat ondanks de voordelige impact van problematiserende scaffolds, geen van beide types scaffolds studenten aanzetten tot een gebalanceerd gebruik van metacognitieve regulatie. Integendeel, de aangereikte problematiserende scaffolds versterkten voornamelijk het natuurlijk potentieel van RPT (zoals vastgesteld in de eerste en tweede onderzoekslijn), maar slaagden er niet in regulatiegedrag uit te lokken dat minder of niet spontaan werd gedemonstreerd door RPT-participanten. Een mogelijke verklaring hiervoor kan gezocht worden in het statische karakter van de metacognitieve scaffolds in de studies. Adequate ondersteuning van complexe regulatieactiviteiten vraagt immers om dynamische begeleiding, aangepast aan de veranderende leer- en regulatienoden van de betrokken studenten (Molenaar et al., 2014; Pea, 2004; Puntambekar & Hübscher, 2005).

Onderzoekslijn 4: Het identificeren van de correlaten van het metacognitief regulatiegedrag van RPT-groepen

De vierde onderzoekslijn focuste niet zozeer op het analyseren van de metacognitieve impact van RPT, maar trachtte veeleer het metacognitief potentieel van RPT te verklaren door te onderzoeken welke onderliggende procesfactoren en interactiekenmerken van het collaboratief leren samenhangen met het gebruik van metacognitieve regulatie. De aandacht ging meer specifiek uit naar het bestuderen van de relatie tussen de door de RPT-groepen gehanteerde kennisverwerkingsstrategieën (i.e. vragen stellen en verduidelijking geven) en de mate van transactiviteit in hun peerdiscussies enerzijds en hun gebruik van basisregulatievaardigheden, diepgaande regulatiestrategieën en sociaal gedeelde metacognitieve regulatie anderzijds. In het kader van de vierde onderzoekslijn werden twee empirische studies uitgevoerd, die staan beschreven in hoofdstukken 8 en 9. Voor beide studies participeerden 64 Schakelstudenten Pedagogische Wetenschappen in een semesterlange RPT-interventie in vaste groepen van zes studenten. Alle RPT-sessies van vijf at random geselecteerde RPT-groepen (30 studenten) werden integraal opgenomen op video. Zowel het metacognitief regulatiegedrag, de gehanteerde kennisverwerkingsstrategieën als de mate van transactiviteit in de peerdiscussies van RPT-participanten werden gemeten aan de hand van observatie van de geverbaliseerde interacties tussen tutors en tutees. Om de bovengenoemde relaties te onderzoeken werd gebruik gemaakt van binaire logistische regressieanalyses.

De vierde onderzoekslijn toonde aan dat het gebruik van metacognitieve regulatie significant positief gecorreleerd is met de aangewende kennisverwerkingsstrategieën van RPT-groepen. Het stellen van vragen was meer specifiek belangrijk voor het aanwenden van monitoring, terwijl het geven van verduidelijking positief geassocieerd was met oriënteren en evalueren. Plannen bleek daarentegen niet significant gerelateerd aan het gebruik van kennisverwerkingsstrategieën. De resultaten toonden verder aan dat diepgaande kennisverwerkingsstrategieën (i.e. vraagstelling en verduidelijking gericht op integratie en elaboratie van kennis en leerinhouden) RPT-participanten aanmoedigden tot het gebruik van diepgaande regulatiestrategieën tijdens oriënteren en monitoren.

Oppervlakkige kennisverwerkingsstrategieën (i.e. vraagstelling en verduidelijking gericht op het overdragen of herhalen van feitenkennis) bleken daarentegen significant negatief gecorreleerd met het aanwenden van diepgaande regulatiestrategieën. De resultaten wezen bijkomend uit dat diepgaande kennisverwerkingsstrategieën RPT-participanten eveneens stimuleerden tot betrokkenheid in sociaal gedeelde metacognitieve regulatie.

Op basis van de bevindingen uit de vierde onderzoekslijn kan verder geconcludeerd worden dat non-transactieve discussies, waarin RPT-participanten elkaars bijdragen negeerden, studenten niet aanmoedigden tot (sociaal gedeelde) metacognitieve regulatie. Transactieve discussies, waarin studenten reageerden op elkaar, bleken daarentegen significant positief gecorreleerd met het gebruik van oriënteren, monitoren en sociaal gedeelde metacognitieve regulatie. Engagement in sociaal gedeelde metacognitieve regulatie bleek bovendien beduidend sterker geassocieerd met transactieve discussies gericht op het bespreken van metacognitieve activiteiten in vergelijking met transactieve discussies gericht op cognitieve activiteiten. De resultaten toonden verder aan dat met name operationele transactieve discussies (waarin studenten elaboreerden op de interactieve bijdragen van peers – Berkowitz, Althof, Turner, & Bloch, 2008) belangrijk zijn voor het bevorderen van sociaal gedeelde metacognitieve regulatie. Voor het aanwenden van diepgaande regulatiestrategieën bleek de inhoud van transactieve discussies echter minder doorslaggevend. Representatieve transactieve discussies (waarin studenten elkaars bijdragen parafraseerden of herhaalden – Berkowitz et al., 2008) en operationele transactieve discussies vergrootten de kans op het gebruik van diepgaande regulatiestrategieën immers in dezelfde mate.

Samenvattend kan op basis van de vierde onderzoekslijn geconcludeerd worden dat de onderliggende dynamieken die het collaboratief leerproces tijdens RPT karakteriseerden, het gebruik van metacognitieve regulatie door tutors en tutees in belangrijke mate beïnvloedden. De bevinding dat met name diepgaande kennisverwerkingsstrategieën en operationele transactieve discussies het aanwenden van (sociaal gedeelde) metacognitieve regulatie bevorderden, biedt bovendien concrete en praktische aanknopingspunten om het regulatiegedrag van studenten hoger onderwijs in collaboratieve settings te optimaliseren.

Algemeen besluit

Niettegenstaande collaboratieve leeromgevingen als waardevol worden beschouwd voor het bevorderen van metacognitieve regulatie, is tot op heden weinig empirisch onderzoek beschikbaar dat het metacognitieve regulatiegedrag van collaboratieve leergroepen gedetailleerd in kaart brengt. Dit proefschrift trachtte via een procesgerichte analyse van (sociaal gedeelde) metacognitieve regulatieactiviteiten, aangewend naar aanleiding van deelname aan reciproke peer tutoring (RPT), innovatieve inzichten bij te dragen aan de onderzoeksliteratuur terzake. Het beoogde meer specifiek te onderzoeken of en te verklaren waarom deelname aan RPT een positieve impact genereerde op het gebruik van individuele en sociaal gedeelde metacognitieve regulatie. Daartoe werden acht empirische studies opgezet, ondergebracht in vier overkoepelende onderzoekslijnen. De onderzoekslijnen onderzochten (1) de impact van RPT op het metacognitief regulatiegedrag van individuele studenten; (2) de impact van RPT op het gebruik van metacognitieve regulatie binnen RPT-groepen; (3) de impact van metacognitieve scaffolds op het regulatiegedrag van RPT-groepen; (4) de correlaten van de door RPT-groepen aangewende metacognitieve regulatie. Op basis van de bevindingen kan gesteld worden dat participatie aan RPT zowel het individueel als het sociaal gedeeld metacognitief regulatiegedrag van studenten positief beïnvloedt. Het natuurlijk metacognitief potentieel van RPT kan bovendien worden versterkt door RPT-participanten problematiserende metacognitieve scaffolds aan te reiken. Verder maakten de resultaten duidelijk dat met name het gebruik van diepgaande kennisverwerkingsstrategieën en betrokkenheid in transactieve peerdiscussies het aanwenden van (sociaal gedeelde) metacognitieve regulatie stimuleren.

Hoewel dit proefschrift niet vrij is van (methodologische) beperkingen, draagt het belangrijke inzichten bij die de literatuur omtrent het metacognitief regulatiegedrag van collaboratieve groepen uitbreiden en verdiepen. In dit verband zijn met name de resultaten van de studies omtrent sociaal gedeelde metacognitieve regulatie belangrijk, gezien dit onderzoeksdomein nog volop in ontwikkeling is en empirische bevindingen omtrent het sociaal gedeeld regulatiegedrag van collaboratieve leergroepen bijgevolg schaars zijn. Zowel de beperkingen als de bevindingen van dit proefschrift zetten bijkomend ook concrete krijtlijnen uit voor vervolgonderzoek naar metacognitieve regulatie in collaboratieve settings. Vooral onderzoek naar de invloed van een gedifferentieerde betrokkenheid in sociaal gedeelde metacognitieve regulatie op de leeruitkomsten van zowel individuele studenten als collaboratieve leergroepen is in dit verband wenselijk. Tot slot bieden de bevindingen van het proefschrift concrete aanknopingspunten ter bevordering van het metacognitief regulatiegedrag van studenten in het hoger onderwijs en sporen ze zowel instructieverantwoordelijken als beleidsmakers in het hoger onderwijs aan te investeren in de organisatie en implementatie van RPT.

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Volet, S., Summers, M., & Thurman, J. (2009a). High-level co-regulation in collaborative learning: How does it emerge and how is it sustained? *Learning and Instruction, 19*, 128-143.

Volet, S., Vauras, M., & Salonen, P. (2009b). Self- and social regulation in learning contexts: An integrative perspective. *Educational Psychologist, 44*, 215-226.

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Winne, P.H. & Jamieson-Noel, D. (2002). Exploring students' calibration of self-reports about study tactics and achievement. *Contemporary Educational Psychology, 27,* 551-572.

Zimmerman, B.J. & Schunk, D.H. (2011). Self-regulated learning and performance: An introduction and an overview. In: B.J. Zimmerman & D.H. Schunk (Eds.). *Handbook of self-regulation of learning and performance* (pp. 1-12). New York: Routledge.

Academic output

Academic output

Output integrated in this dissertation

Journals

(a1)

De Backer, L., Van Keer, H., & Valcke, M. (2012). Exploring the potential impact of reciprocal peer tutoring on higher education students' metacognitive knowledge and metacognitive regulation. *Instructional Science, 40*, 559-588.

De Backer, L., Van Keer, H., & Valcke, M. (2015). Socially shared metacognitive regulation during reciprocal peer tutoring: Identifying its relationship with students' content processing and transactive discussions. *Instructional Science, 43*, 323-344.

De Backer, L., Van Keer, H., & Valcke, M. (2015). Exploring evolutions in reciprocal peer tutoring groups' socially shared metacognitive regulation and identifying its metacognitive correlates. *Learning and Instruction, 38*, 63-78.

De Backer, L., Van Keer, H., & Valcke, M. (in press). Promoting university students' metacognitive regulation through peer learning: The potential of reciprocal peer tutoring. Manuscript accepted for publication in *Higher Education*. DOI: 10.1007/s10734-014-9849-3.

De Backer, L., Van Keer, H., Moerkerke, B., & Valcke, M. (in press). Examining evolutions in the adoption of metacognitive regulation in reciprocal peer tutoring groups. Manuscript accepted for publication in *Metacognition and Learning.* DOI: 10.1007/s11409-015-9141-7.

De Backer, L., Van Keer, H., & Valcke, M. (2015). Eliciting reciprocal peer tutoring groups' metacognitive regulation through structuring and problematising scaffolds. Manuscript resubmitted for publication in *The Journal of Experimental Education* (after a second revision based on the reviewers' comments).

De Backer, L., Van Keer, H., & Valcke, M. (2015). Metacognitive regulation during reciprocal peer tutoring: Examining its relationship with students' content processing and transactive discussions. Manuscript submitted for publication in *Higher Education.*

De Backer, L., Van Keer, H., Vandevelde, S., & Valcke, M. (2015). Eliciting co-regulation and socially shared metacognitive regulation through structuring and problematising scaffolds. Manuscript submitted for publication in *Cognition and Instruction.*

(a2)

De Backer, L., Van Keer, H., & Valcke, M. (2012). Van peer tutoring naar metacognitieve regulatie? Een studie naar de potentiële impact van reciproke peer tutoring in het hoger onderwijs. *Tijdschrift voor Hoger Onderwijs, 29,* 224-249.

(p1)

De Backer, L., Van Keer, H., & Valcke, M. (2012). Fostering university students' metacognitive regulation through peer tutoring. *Procedia Social and Behavioural Sciences, 69*, 1594-1600.

Conference contributions

De Backer, L., Van Keer, H., & Valcke, M. (2010). De impact van reciproke peer tutoring op de metacognitie van studenten hoger onderwijs [The impact of reciprocal peer tutoring on higher education students' metacognition]. Paper presented at the Onderwijs Research Dagen (ORD), Enschede, The Netherlands, June 23-25, 2010.

De Backer, L., Van Keer, H., & Valcke, M. (2011). Peer tutoringinteracties als stimulator van metacognitieve regulatievaardigheden? [Peer tutoring interactions as stimulator of metacognitive regulation skills?]. Paper presented at the Onderwijs Research Dagen (ORD), Maastricht, The Netherlands, June 08-10, 2011.

De Backer, L., Van Keer, H., & Valcke, M. (2011). Think peer! The potential of reciprocal peer tutoring in promoting university students' metacognition. Paper presented at the 14th Biennial Conference of the European Association for Research on Learning and Instruction (EARLI), Exeter, United Kingdom, August 30–September 3, 2011.

De Backer, L., Van Keer, H., & Valcke, M. (2012). Peer tutoring interactions as stimulator of metacognitive regulation? Paper presented at the Annual Meeting of the American Educational Research Association (AERA), Vancouver, Canada, April 13-17, 2012.

De Backer, L., Van Keer, H., & Valcke, M. (2012). Peer tutoring groups as metacognitive learning environments? Poster presented at the 5th Biennial Meeting of the Special Interest Group (SIG) 16 Metacognition of the European Association for Research on Learning and Instruction (EARLI), Milan, Italy, September 5-8 , 2012.

De Backer, L., Van Keer, H., & Valcke, M. (2012). Fostering university students' metacognitive regulation through peer tutoring. Paper presented at The International Conference on Education and Educational Psychology (ICEEPSY), Istanbul, Turkey, October 10-13, 2012.

De Backer, L., Van Keer, H., & Valcke, M. (2013). Exploring evolutions in reciprocal peer tutoring groups' metacognitive regulation: An interaction analysis. Paper presented at the Annual Meeting of the American Educational Research Association (AERA), San Francisco, USA, April 27 – May 1, 2013.

De Backer, L., Van Keer, H., & Valcke, M. (2013). From peer tutoring to metacognitive regulation: The impact of reciprocal peer tutoring. Poster presented at the Annual Meeting of the American Educational Research Association (AERA), San Francisco, USA, April 27 – May 1, 2013.

De Backer, L., Van Keer, H., & Valcke, M. (2013). University students learning to regulate together: Evolutions in reciprocal peer tutoring groups' metacognitive regulation. Paper presented at the 16th Biennial Conference on Teachers and Teaching (ISATT), Ghent, Belgium, July 1-5, 2013.

De Backer, L., Van Keer, H., & Valcke, M. (2013). Learning to regulate from peers? An analysis on peer tutoring groups' metacognitive regulation. Paper presented at the 15th Biennial Conference of the European Association for Research on Learning and Instruction (EARLI), Munich, Germany, August 27-31, 2013.

De Backer, L., Van Keer, H., & Valcke, M. (2013). Peers learning to regulate together? Evolutions in reciprocal peer tutoring groups' socially shared regulation. Poster presented at the 15th Biennial Conference of the European Association for Research on Learning and Instruction (EARLI), Munich, Germany, August 27-31, 2013.

De Backer, L., Van Keer, H., & Valcke, M. (2014). Exploring the relations between reciprocal peer tutoring groups' metacognitive regulation, cognitive processing, and transactive discussions. Paper presented at the Annual Meeting of the American Educational Research Association (AERA), Philadelphia, USA, April 3-7, 2014.

De Backer, L., Van Keer, H., & Valcke, M. (2014). Uncovering evolutions in reciprocal peer tutoring groups' socially shared regulation. Poster presented at the Annual Meeting of the American Educational Research Association (AERA), Philadelphia, USA, April 3-7, 2014.

De Backer, L., Van Keer, H., & Valcke, M. (2014). Socially shared metacognitive regulation in higher education reciprocal peer tutoring groups: Unravelling its correlates. Paper presented at the 6th Biennial Meeting of the Special Interest Group (SIG) 16 Metacognition of the European Association for Research on Learning and Instruction (EARLI), Istanbul, Turkey, September 3-6, 2014.

De Backer, L., Van Keer, H., & Valcke, M. (2015). Not all of collaborative learners' metacognitive regulation is socially shared: A study of reciprocal peer tutoring groups. Poster presented at the Annual Meeting of the American Educational Research Association (AERA), Chicago, USA, April 16-20, 2015.

De Backer, L., Van Keer, H., & Valcke, M. (2015). Portraying peer tutoring groups' evolutions towards socially shared metacognitive regulation. Paper accepted for presentation at the 16th Biennial Conference of the European Association for Research on Learning and Instruction (EARLI), Limassol, Cyprus, August 25-29, 2015.

De Backer, L., Van Keer, H., & Valcke, M. (2015). Which regulation behaviour is shared? A study in reciprocal peer tutoring groups. Paper accepted for presentation at the 16th Biennial Conference of the European Association for Research on Learning and Instruction (EARLI), Limassol, Cyprus, August 25-29, 2015.

Other academic output

Journals

(a1)

Vandevelde, S., Van Keer, H., De Backer, L., Van Steenbrugge, H., & Mertens, C. (2015). Unravelling tutoring processes during student tutoring focusing on self-regulated learning. Manuscript submitted for publication in *The Elementary School Journal.*

(a4)

De Backer, L. & Van Keer, H. (2009). Studenten maken het verschil. *Welwijs, 20*, 12-15.

Chapters in books

(b2)

De Backer, L. & Van Keer, H. (2008). Student tutoring: of hoe studenten de onderwijskansen van allochtone en/of kansarme leerlingen kunnen bevorderen (pp.37-54). *Praktijkgids voor de Basisschool.* Mechelen: Plantyn nv.

De Backer, L. & Van Keer, H. (2009). Tutors aan de slag met kansarme en/of allochtone leerlingen: mogelijkheden, succesfactoren en randvoorwaarden van student tutoring in het (secundair) onderwijs (pp.19-44). *Handboek Leerlingenbegeleiding.* Mechelen: Plantyn nv.

Miscellaneous

(V)

De Backer, L. & Van Keer, H. (2008). *Tutors maken het verschil. Tutoring- en begeleidingsinitiatieven in het Vlaamse onderwijs.* Brussel: Koning Boudewijnstichting.

Sante, E., Hermans, R., De Backer, L., & Van Keer, H. (2009). *Student tutoring: Veel kansen in één. Een effectenstudie bij student tutoringinitiatieven in het Vlaamse onderwijs.* Brussel: Koning Boudewijnstichting.

Data storage fact sheets

% Data Storage Fact Sheet

% Name/identifier study
% Author: Liesje De Backer
% Date: February, 26, 2015

1. Contact details
==
1a. Main researcher

- name: Liesje De Backer
- address:Henri Dunantlaan 2 - 9000 Ghent - Belgium
- e-mail: Liesje.DeBacker@UGent.be

1b. Responsible Staff Member (ZAP)

- name: Martin Valcke (promotor PhD project)
- address: Henri Dunantlaan 2 - 9000 Ghent - Belgium
- e-mail: Martin.Valcke@UGent.be

If a response is not received when using the above contact details, please send an email to data.pp@ugent.be or contact Data Management, Faculty of Psychology and Educational Sciences, Henri Dunantlaan 2, 9000 Ghent, Belgium.

2. Information about the datasets to which this sheet applies
==
* Reference of the publication in which the datasets are reported:
De Backer, L., Van Keer, H., & Valcke, M. (2012). Exploring the potential impact of reciprocal peer tutoring on higher education students' metacognitive knowledge and metacognitive regulation. *Instructional Science, 40*, 559-588.

* Which datasets in that publication does this sheet apply to?:
Both datasets included in the study reported in Chapter 2 of the dissertation

3. Information about the files that have been stored
==
3a. Raw data
----
* Have the raw data been stored by the main researcher? [X] YES / [ ] NO
If NO, please justify:

* On which platform are the raw data stored?
1. Student survey data:
 - [ ] researcher PC
 - [ ] research group file server
 - [X] other (specify): stored in the researcher's office

2. Video data of think-aloud protocols
 - [X] researcher PC
 - [ ] research group file server
 - [X] other (specify): external hard disk and dvd's stored in the researcher's office

* Who has direct access to the raw data (i.e., without intervention of another person)?
 - [X] main researcher
 - [ ] responsible ZAP
 - [ ] all members of the research group
 - [ ] all members of UGent
 - [ ] other (specify): ...

3b. Other files

----

* Which other files have been stored?
 - [X] file(s) describing the transition from raw data to reported results. Specify: A coding scheme adopted to analyse the data from the think-aloud protocols was stored
 - [X] file(s) containing processed data. Specify: student survey data was processed (i.e. cleaned data in SPSS, aggregated for analysis); all think-aloud protocols were transcribed and stored as Word files; all think-aloud protocol data was processed (i.e. cleaned data in SPSS, aggregated for analysis)
 - [X] file(s) containing analyses. Specify: all SPSS-generated output was saved in SPSS; a selection of SPSS-generated output (i.e. output of preliminary analyses as well as output of the main analyses providing answers to the research questions posed) was stored as Word files
 -[ ] files(s) containing information about informed consent
 -[ ] a file specifying legal and ethical provisions
 -[ ] file(s) that describe the content of the stored files and how this content should be interpreted. Specify: ...
 -[ ] other files. Specify: ...

* On which platform are these other files stored?
 - [X] individual PC
 - [ ] research group file server
 - [ ] other: ...

* Who has direct access to these other files (i.e., without intervention of another person)?
 - [X] main researcher
 - [ ] responsible ZAP
 - [ ] all members of the research group
 - [ ] all members of UGent
 - [ ] other (specify): ...

4. Reproduction

===

* Have the results been reproduced independently?: [ ] YES / [X] NO
* If yes, by whom (add if multiple):
  - name:
  - address:
  - affiliation:
  - e-mail:

% Data Storage Fact Sheet

% Name/identifier study
% Author: Liesje De Backer
% Date: February, 26, 2015

1. Contact details
===

1a. Main researcher

- name: Liesje De Backer
- address:Henri Dunantlaan 2 - 9000 Ghent - Belgium
- e-mail: Liesje.DeBacker@UGent.be

1b. Responsible Staff Member (ZAP)

- name: Martin Valcke (promotor PhD project)
- address: Henri Dunantlaan 2 - 9000 Ghent - Belgium
- e-mail: Martin.Valcke@UGent.be

If a response is not received when using the above contact details, please send an email to data.pp@ugent.be or contact Data Management, Faculty of Psychology and Educational Sciences, Henri Dunantlaan 2, 9000 Ghent, Belgium.

2. Information about the datasets to which this sheet applies
===

* Reference of the publication in which the datasets are reported:
De Backer, L., Van Keer, H., & Valcke, M. (in press). Promoting university students' metacognitive regulation through peer learning: The potential of peer tutoring. Manuscipt accepted for publication in *Higher Education.* Doi: 10.1007/s10734-014-9849-3.

* Which datasets in that publication does this sheet apply to?:
Datasets from all research groups included in the study reported in Chapter 3 of the dissertation

3. Information about the files that have been stored
===

3a. Raw data
----

* Have the raw data been stored by the main researcher? [X] YES / [ ] NO
If NO, please justify:

* On which platform are the raw data stored?
1. Video data of think-aloud protocols
  - [X] researcher PC
  - [ ] research group file server
  - [X] other (specify): external hard disk and dvd's stored in the researcher's office

* Who has direct access to the raw data (i.e., without intervention of another person)?
  - [X] main researcher
  - [ ] responsible ZAP
  - [ ] all members of the research group
  - [ ] all members of UGent
  - [ ] other (specify): ...

3b. Other files

----

* Which other files have been stored?
  - [X] file(s) describing the transition from raw data to reported results. Specify: A coding scheme adopted to analyse the data from the think-aloud protocols was stored
  - [X] file(s) containing processed data. Specify: all think-aloud protocols were transcribed and stored as Word files; all think-aloud protocol data was processed (i.e. cleaned data in SPSS, aggregated for analysis)
  - [X] file(s) containing analyses. Specify: all SPSS-generated output was saved in SPSS; a selection of SPSS-generated output (i.e. output of preliminary analyses as well as output of the main analyses providing answers to the research questions posed) was stored as Word files
  -[ ] files(s) containing information about informed consent
  -[ ] a file specifying legal and ethical provisions
  -[ ] file(s) that describe the content of the stored files and how this content should be interpreted. Specify: ...
  - [ ] other files. Specify: ...

* On which platform are these other files stored?
  - [X] individual PC
  - [ ] research group file server
  - [ ] other: ...

* Who has direct access to these other files (i.e., without intervention of another person)?
  - [X] main researcher
  - [ ] responsible ZAP
  - [ ] all members of the research group
  - [ ] all members of UGent
  - [ ] other (specify): ...

4. Reproduction

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* Have the results been reproduced independently?: [ ] YES / [X] NO
* If yes, by whom (add if multiple):
  - name:
  - address:
  - affiliation:
  - e-mail:

% Data Storage Fact Sheet

% Name/identifier study
% Author: Liesje De Backer
% Date: February, 26, 2015

1. Contact details

===

1a. Main researcher

- name: Liesje De Backer
- address:Henri Dunantlaan 2 - 9000 Ghent - Belgium
- e-mail: Liesje.DeBacker@UGent.be

1b. Responsible Staff Member (ZAP)

- name: Martin Valcke (promotor PhD project)
- address: Henri Dunantlaan 2 - 9000 Ghent - Belgium
- e-mail: Martin.Valcke@UGent.be

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2. Information about the datasets to which this sheet applies

===

* Reference of the publication in which the datasets are reported:
De Backer, L., Van Keer, H., Moerkerke, B., & Valcke, M. (in press). Examining evolutions in the adoption of metacognitive regulation in reciprocal peer tutoring groups. Manuscipt accepted for publication in *Metacognition and Learning*. DOI: 10.1007/s11409-015-9141-7.

* Which datasets in that publication does this sheet apply to?:
The complete dataset of the study reported in Chapter 4 of the dissertation

3. Information about the files that have been stored

===

3a. Raw data

----

* Have the raw data been stored by the main researcher? [X] YES / [ ] NO
If NO, please justify:

* On which platform are the raw data stored?

1. Video data of 7 reciprocal peer tutoring (RPT) sessions of 5 RPT-groups
  - [X] researcher PC
  - [ ] research group file server
  - [X] other (specify): external hard disk and dvd's stored in the researcher's office

* Who has direct access to the raw data (i.e., without intervention of another person)?
  - [X] main researcher
  - [ ] responsible ZAP
  - [ ] all members of the research group
  - [ ] all members of UGent
  - [ ] other (specify): ...

3b. Other files

----

* Which other files have been stored?
  - [X] file(s) describing the transition from raw data to reported results. Specify: a coding scheme adopted to analyse the videotaped RPT-sessions was stored as a Word file; R syntax files were stored for each dependent variable included in the analyses
  - [X] file(s) containing processed data. Specify: the coded RPT-sessions were stored as Nvivo files; all coded video data was processed (i.e. cleaned data in SPSS, transformed into .csv-file format in Excel, aggregated for analysis in R)
  - [X] file(s) containing analyses. Specify: the integral R-generated output for all preliminary and main analyses conducted was stored as Word files; a selection of R-generated output (i.e. output of the main analyses providing answers to the research questions posed) was stored as Word files; all generated graphs describing evolution patterns were stored as pdf-files and jpeg-files; the output of descriptive analyses for each seperate RPT-group and each RPT-session was stored as a Word file
  -[ ] files(s) containing information about informed consent
  -[ ] a file specifying legal and ethical provisions
  -[ ] file(s) that describe the content of the stored files and how this content should be interpreted. Specify: ...
  -[ ] other files. Specify: ...

* On which platform are these other files stored?
  - [X] individual PC
  - [ ] research group file server
  - [X] other: the cleaned and aggregated datafile used for analysis in R, as well as the R syntax for the variable "MCR_total" are also stored on the individual PC of Beatrijs Moerkerke

* Who has direct access to these other files (i.e., without intervention of another person)?
  - [X] main researcher
  - [ ] responsible ZAP
  - [ ] all members of the research group
  - [ ] all members of UGent
  - [X] other (specify): Beatrijs Moerkerke has direct access to the cleaned and aggregated datafile used for analysis in R, as well as to the R syntax file for the variable "MCR_total"

4. Reproduction
==
* Have the results been reproduced independently?: [X] YES / [ ] NO
The results regarding time-bound evolutions in the frequency of occurrence of RPT-groups' metacognitive regulation have been reproduced for the dependent variable "MCR_total"

* If yes, by whom (add if multiple):
  - name: Beatrijs Moerkerke
  - address: Henri Dunantlaan 1 - 9000 Ghent - Belgium
  - affiliation: Department of Data Analysis - Faculty of Psychology and Edcuational Sciences – Ghent University
  - e-mail: Beatrijs.Moerkerke@UGent.be

% Data Storage Fact Sheet

% Name/identifier study
% Author: Liesje De Backer
% Date: February, 26, 2015

1. Contact details
===

1a. Main researcher

- name: Liesje De Backer
- address:Henri Dunantlaan 2 - 9000 Ghent - Belgium
- e-mail: Liesje.DeBacker@UGent.be

1b. Responsible Staff Member (ZAP)

- name: Martin Valcke (promotor PhD project)
- address: Henri Dunantlaan 2 - 9000 Ghent - Belgium
- e-mail: Martin.Valcke@UGent.be

If a response is not received when using the above contact details, please send an email to data.pp@ugent.be or contact Data Management, Faculty of Psychology and Educational Sciences, Henri Dunantlaan 2, 9000 Ghent, Belgium.

2. Information about the datasets to which this sheet applies
===

* Reference of the publication in which the datasets are reported:
De Backer, L., Van Keer, H., & Valcke, M. (2015). Exploring evolutions in reciprocal peer tutoring groups' socially shared metacognitive regulation and identifying its metacognitive correlates. *Learning and Instrcution,* 38, 63-78.

* Which datasets in that publication does this sheet apply to?:
The complete dataset of the study reported in Chapter 5 of the dissertation

3. Information about the files that have been stored
===

3a. Raw data
----

* Have the raw data been stored by the main researcher? [X] YES / [ ] NO
If NO, please justify:

* On which platform are the raw data stored?

1. Video data of 7 reciprocal peer tutoring (RPT) sessions of 5 RPT-groups
  - [X] researcher PC
  - [ ] research group file server
  - [X] other (specify): external hard disk and dvd's stored in the researcher's office

* Who has direct access to the raw data (i.e., without intervention of another person)?
  - [X] main researcher
  - [ ] responsible ZAP
  - [ ] all members of the research group
  - [ ] all members of UGent
  - [ ] other (specify): ...

3b. Other files

----

* Which other files have been stored?
  - [X] file(s) describing the transition from raw data to reported results. Specify: a coding scheme adopted to analyse the videotaped RPT-sessions was stored as a Word file; R syntax files were stored for each dependent variable included in the analyses
  - [X] file(s) containing processed data. Specify: the coded RPT-sessions were stored as Nvivo files; all video data was processed (i.e. cleaned data in SPSS, transformed into .csv-file format in Excel, aggregated for analysis in R)
  - [X] file(s) containing analyses. Specify: the integral R-generated output for all preliminary and main analyses conducted was stored as Word files; a selection of R-generated output (i.e. output of the main analyses providing answers to the research questions posed) was stored as Word files; all generated graphs describing evolution patterns were stored as pdf-files and jpeg-files
  -[ ] files(s) containing information about informed consent
  -[ ] a file specifying legal and ethical provisions
  -[ ]file(s) that describe the content of the stored files and how this content should be interpreted. Specify: ...
  - [ ] other files. Specify: ...

* On which platform are these other files stored?
  - [X] individual PC
  - [ ] research group file server
  - [ ] other (specify):

* Who has direct access to these other files (i.e., without intervention of another person)?
  - [X] main researcher
  - [ ] responsible ZAP
  - [ ] all members of the research group
  - [ ] all members of UGent
  - [ ] other (specify):

4. Reproduction

===

* Have the results been reproduced independently?: [ ] YES / [X] NO

* If yes, by whom (add if multiple):
   - name:
   - address:
   - affiliation:
   - e-mail:

% Data Storage Fact Sheet

% Name/identifier study
% Author: Liesje De Backer
% Date: February, 26, 2015

1. Contact details
==

1a. Main researcher

- name: Liesje De Backer
- address:Henri Dunantlaan 2 - 9000 Ghent - Belgium
- e-mail: Liesje.DeBacker@UGent.be

1b. Responsible Staff Member (ZAP)

- name: Martin Valcke (promotor PhD project)
- address: Henri Dunantlaan 2 - 9000 Ghent - Belgium
- e-mail: Martin.Valcke@UGent.be

If a response is not received when using the above contact details, please send an email to data.pp@ugent.be or contact Data Management, Faculty of Psychology and Educational Sciences, Henri Dunantlaan 2, 9000 Ghent, Belgium.

2. Information about the datasets to which this sheet applies
==

* Reference of the publication in which the datasets are reported:
De Backer, L., Van Keer, H., & Valcke, M. (2015). Eliciting reciprocal peer tutoring groups' metacognitive regulation through structuring and problematising scaffolds. Manuscipt resubmitted for publication.

* Which datasets in that publication does this sheet apply to?:
The complete dataset of the study reported in Chapter 6 of the dissertation

3. Information about the files that have been stored
==

3a. Raw data
----

* Have the raw data been stored by the main researcher? [X] YES / [ ] NO
If NO, please justify:

* On which platform are the raw data stored?
1. Video data of 3 reciprocal peer tutoring (RPT) sessions of 8 RPT-groups
  - [X] researcher PC
  - [ ] research group file server
  - [X] other (specify): external hard disk and dvd's stored in the researcher's office

* Who has direct access to the raw data (i.e., without intervention of another person)?
  - [X] main researcher
  - [ ] responsible ZAP
  - [ ] all members of the research group
  - [ ] all members of UGent
  - [ ] other (specify): ...

3b. Other files
----
* Which other files have been stored?
  - [X] file(s) describing the transition from raw data to reported results. Specify: a coding scheme adopted to analyse the videotaped RPT-sessions was stored as a Word file
  - [X] file(s) containing processed data. Specify: an Excel file was stored representing the coded video data; all video data was processed, cleaned data in SPSS aggregated for analysis was stored as .sav file
  - [X] file(s) containing analyses. Specify: the integral SPSS-generated output for all preliminary and main analyses conducted was stored in SPSS; a selection of SPSS-generated output (i.e. output of the main analyses providing answers to the research questions posed) was stored as Word files
  -[ ] files(s) containing information about informed consent
  -[ ] a file specifying legal and ethical provisions
  -[ ] file(s) that describe the content of the stored files and how this content should be interpreted. Specify: ...
  - [ ] other files. Specify: ...

* On which platform are these other files stored?
  - [X] individual PC
  - [ ] research group file server
  - [ ] other (specify):

* Who has direct access to these other files (i.e., without intervention of another person)?
  - [X] main researcher
  - [ ] responsible ZAP
  - [ ] all members of the research group
  - [ ] all members of UGent
  - [ ] other (specify):

4. Reproduction
===
* Have the results been reproduced independently?: [ ] YES / [X] NO
* If yes, by whom (add if multiple):

  - name:
  - address:
  - affiliation:
  - e-mail:

% Data Storage Fact Sheet

% Name/identifier study
% Author: Liesje De Backer
% Date: February, 26, 2015

1. Contact details
===

1a. Main researcher

- name: Liesje De Backer
- address:Henri Dunantlaan 2 - 9000 Ghent - Belgium
- e-mail: Liesje.DeBacker@UGent.be

1b. Responsible Staff Member (ZAP)

- name: Martin Valcke (promotor PhD project)
- address: Henri Dunantlaan 2 - 9000 Ghent - Belgium
- e-mail: Martin.Valcke@UGent.be

If a response is not received when using the above contact details, please send an email to data.pp@ugent.be or contact Data Management, Faculty of Psychology and Educational Sciences, Henri Dunantlaan 2, 9000 Ghent, Belgium.

2. Information about the datasets to which this sheet applies
===

* Reference of the publication in which the datasets are reported:
De Backer, L., Van Keer, H., Vandevelde, S., & Valcke, M. (2015). Eliciting co-regulation and socially shared metacognitive regulation through structuring and problematising scaffolds. Manuscipt submitted for publication.

* Which datasets in that publication does this sheet apply to?:
The complete dataset of the study reported in Chapter 7 of the dissertation

3. Information about the files that have been stored
===

3a. Raw data
----

* Have the raw data been stored by the main researcher? [X] YES / [ ] NO
If NO, please justify:

* On which platform are the raw data stored?
1. Video data of 3 reciprocal peer tutoring (RPT) sessions of 8 RPT-groups
  - [X] researcher PC
  - [ ] research group file server
  - [X] other (specify): external hard disk and dvd's stored in the researcher's office

* Who has direct access to the raw data (i.e., without intervention of another person)?
 - [X] main researcher
 - [ ] responsible ZAP
 - [ ] all members of the research group
 - [ ] all members of UGent
 - [ ] other (specify): ...

3b. Other files
----

* Which other files have been stored?
 - [X] file(s) describing the transition from raw data to reported results. Specify: a coding scheme adopted to analyse the videotaped RPT-sessions was stored as a Word file
 - [X] file(s) containing processed data. Specify: an Excel file was stored representing the coded video data; all video data was processed, cleaned data in SPSS aggregated for analysis was stored as .sav file
 - [X] file(s) containing analyses. Specify: the integral SPSS-generated output for all preliminary and main analyses conducted was stored in SPSS; a selection of SPSS-generated output (i.e. output of the main analyses providing answers to the research questions posed) was stored as Word files
 -[ ] files(s) containing information about informed consent
 -[ ] a file specifying legal and ethical provisions
 -[ ] file(s) that describe the content of the stored files and how this content should be interpreted. Specify: ...
 -[ ] other files. Specify: ...

* On which platform are these other files stored?
 - [X] individual PC
 - [ ] research group file server
 - [ ] other (specify):

* Who has direct access to these other files (i.e., without intervention of another person)?
 - [X] main researcher
 - [ ] responsible ZAP
 - [ ] all members of the research group
 - [ ] all members of UGent
 - [ ] other (specify):

4. Reproduction
==

* Have the results been reproduced independently?: [ ] YES / [X] NO

* If yes, by whom (add if multiple):
 - name:
 - address:
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% Data Storage Fact Sheet

% Name/identifier study
% Author: Liesje De Backer
% Date: February, 26, 2015

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- address:Henri Dunantlaan 2 - 9000 Ghent - Belgium
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2. Information about the datasets to which this sheet applies
===

* Reference of the publication in which the datasets are reported:
De Backer, L., Van Keer, H., & Valcke, M. (2015). Metacognitive regulation during reciprocal peer tutoring: Examining its relationship with students' content processing and transactive discussions. Manuscript submitted for publication.

* Which datasets in that publication does this sheet apply to?:
The complete dataset of the study reported in Chapter 8 of the dissertation

3. Information about the files that have been stored
===

3a. Raw data
----

* Have the raw data been stored by the main researcher? [X] YES / [ ] NO
If NO, please justify:

* On which platform are the raw data stored?

1. Video data of 7 reciprocal peer tutoring (RPT) sessions of 5 RPT-groups
  - [X] researcher PC
  - [ ] research group file server
  - [X] other (specify): external hard disk and dvd's stored in the researcher's office

* Who has direct access to the raw data (i.e., without intervention of another person)?
  - [X] main researcher
  - [ ] responsible ZAP
  - [ ] all members of the research group
  - [ ] all members of UGent
  - [ ] other (specify): ...

3b. Other files
----

* Which other files have been stored?
  - [X] file(s) describing the transition from raw data to reported results. Specify: three coding schemes adopted to analyse the videotaped RPT-sessions were stored as Word files (i.e. coding scheme on metacognitive regulation, content processing, and transactive discussions, respectively)
  - [X] file(s) containing processed data. Specify: the coded RPT-sessions were stored as Nvivo files; all video data was processed, cleaned data in SPSS aggregated for analysis was stored as .sav file
  - [X] file(s) containing analyses. Specify: the integral SPSS-generated output for all preliminary and main analyses conducted was stored in SPSS; a selection of SPSS-generated output (i.e. output of the main analyses providing answers to the research questions posed) was stored as Word files
  -[ ] files(s) containing information about informed consent
  -[ ] a file specifying legal and ethical provisions
  -[ ] file(s) that describe the content of the stored files and how this content should be interpreted. Specify: ...
  -[ ] other files. Specify: ...

* On which platform are these other files stored?
  - [X] individual PC
  - [ ] research group file server
  - [ ] other (specify):

* Who has direct access to these other files (i.e., without intervention of another person)?
  - [X] main researcher
  - [ ] responsible ZAP
  - [ ] all members of the research group
  - [ ] all members of UGent
  - [ ] other (specify):

4. Reproduction
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* Have the results been reproduced independently?: [ ] YES / [X] NO

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   - address:
   - affiliation:
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% Data Storage Fact Sheet

% Name/identifier study
% Author: Liesje De Backer
% Date: February, 26, 2015

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1a. Main researcher

- name: Liesje De Backer
- address:Henri Dunantlaan 2 - 9000 Ghent - Belgium
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2. Information about the datasets to which this sheet applies
===

* Reference of the publication in which the datasets are reported:
De Backer, L., Van Keer, H., & Valcke, M. (2015). Socially shared metacognitive regulation during reciprocal peer tutoring: Identifying its relationship with students' content processing and transactive discussions. *Instructional Science, 43*, 323-344.

* Which datasets in that publication does this sheet apply to?:
The complete dataset of the study reported in Chapter 9 of the dissertation

3. Information about the files that have been stored
===

3a. Raw data
----

* Have the raw data been stored by the main researcher? [X] YES / [ ] NO
If NO, please justify:

* On which platform are the raw data stored?

1. Video data of 7 reciprocal peer tutoring (RPT) sessions of 5 RPT-groups
  - [X] researcher PC
  - [ ] research group file server
  - [X] other (specify): external hard disk and dvd's stored in the researcher's office

* Who has direct access to the raw data (i.e., without intervention of another person)?
  - [X] main researcher
  - [ ] responsible ZAP
  - [ ] all members of the research group
  - [ ] all members of UGent
  - [ ] other (specify): ...

3b. Other files
----

* Which other files have been stored?
  - [X] file(s) describing the transition from raw data to reported results. Specify: three coding schemes adopted to analyse the videotaped RPT-sessions were stored as Word files (i.e. coding scheme on SSMR, content processing, and transactive discussions, respectively)
  - [X] file(s) containing processed data. Specify: the coded RPT-sessions were stored as Nvivo files; all video data was processed, cleaned data in SPSS aggregated for analysis was stored as .sav file
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  -[ ] other files. Specify: ...

* On which platform are these other files stored?
  - [X] individual PC
  - [ ] research group file server
  - [ ] other (specify):

* Who has direct access to these other files (i.e., without intervention of another person)?
  - [X] main researcher
  - [ ] responsible ZAP
  - [ ] all members of the research group
  - [ ] all members of UGent
  - [ ] other (specify):

4. Reproduction
===

* Have the results been reproduced independently?: [ ] YES / [X] NO

* If yes, by whom (add if multiple):
   - name:
   - address:
   - affiliation:
   - e-mail: